

INSTRUCTION MANUAL

E-1

AILTECH

Model 650-10 Plug-In Unit

FOR

MODEL 650 SWEEP OSCILLATOR

MANUAL # 110-6006

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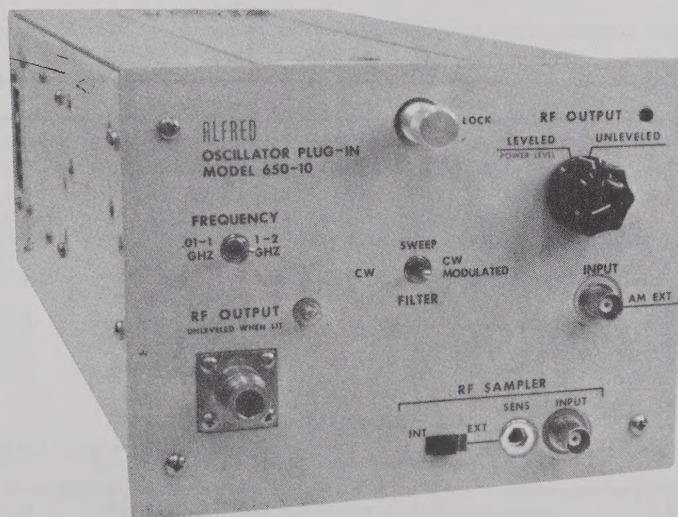
Eaton Corporation
Electronic Instrumentation Division
Los Angeles, California 90066



INSTRUCTION MANUAL

Model 650-10 Plug-In Unit FOR MODEL 650 SWEEP OSCILLATOR

MANUAL # 110-6006



Manual 650-10

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SINGER
INSTRUMENTATION

The Singer Company, Palo Alto Operation

3176 Porter Drive, Palo Alto, California 94304 / (415) 493-3231 TWX 910-373-1765

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- (2) Include data on symptoms, measurements taken, test instruments used, suspected location of trouble, maintenance action taken, and any other relevant data.

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Table 1-1. Tentative Specifications for Model 650-10 Plug-in Unit.

FREQUENCY RANGE:

Band 1 : 10 MHz - 1000 MHz (1 GHz)
Band 2 : 1 GHz - 2 GHz

FREQUENCY ACCURACY, single-frequency mode with FILTER switch in CW position:

Band 1 : ± 10 MHz - ± 20 MHz, proportional to frequency
Band 2 : $\pm 1\%$

POWER OUTPUT, Leveled (minimum):

Band 1 : 5 mw
Band 2 : 50 mw

LEVELED POWER VARIATION, with Internal Leveling (db):

Band 1 : ± 0.5 db
Band 2 : ± 0.7 db

UNLEVELED POWER VARIATION:

5 db, either band

UNLEVELED POWER SLOPE:

1 db/100 MHz, either band

POWER CONTROL RANGE:

Leveled: greater than 15 db
Unleveled: greater than 20 db

SPURIOUS SIGNALS:

Non harmonic: 35 db below fundamental
Harmonic: 20 db below fundamental

SWEEP LINEARITY:

Band 1 : Not rated
Band 2 : 1%

RESIDUAL FM, Peak:

5 KHz, either band

POWER DRIFT:

± 0.05 db/ $^{\circ}$ C, 0 to 55 $^{\circ}$ C, either band

FREQUENCY DRIFT:

With temperature: $\pm 0.03\%/^{\circ}$ C, either band
With time: $\pm 0.005\%/hr$ at 25 $^{\circ}$ C, either band
With line voltage: ± 10 KHz with line voltage 106 - 128 V, either band

FREQUENCY SENSITIVITY TO LOAD:

$< \pm 0.5$ MHz at SWR up to 3.0:1, either band

FREQUENCY VARIATION WITH 10 db POWER CONTROL

$< \pm 0.2$ MHz, either band

AMPLITUDE MODULATION:

Internal on/off square wave or external on/off modulation with < 25 μ s rise and fall times.

EXTERNAL SAMPLER INPUT REQ'D FOR LEVELING:

- 100 mv required at rated output, either band;
1.5K ohms input impedance.

TEMPERATURE RANGE:

Operating, 0 to 55 $^{\circ}$ C
Non-operating, - 25 to + 75 $^{\circ}$ C

OTHER SPECIFICATIONS ARE AS PUBLISHED FOR MODEL 650 SERIES.

SECTION 1

GENERAL INFORMATION

1.1 SCOPE OF MANUAL.

This manual covers the Model 650-10 Oscillator Plug-in unit for the ALFRED Model 650 Sweep Oscillator.

Table 1-1 provides specifications and performance information pertinent to the Model 650-10 plug-in unit.

This manual should be used as a supplement to the basic Model 650 Instruction Manual. That manual includes all necessary information for operating the Model 650 with any plug-in unit installed. This plug-in unit manual gives supplemental descriptive, theory, and maintenance information pertinent to the various modes of operation provided by the broadband, solid-state Model 650-10.

1.2 DESCRIPTION OF PLUG-IN UNIT.

Each Model 650 Series plug-in unit is a modular rf head assembly designed to operate with the ALFRED Model 650 main frame to constitute an rf or microwave sweep oscillator. The Model 650-10 uses two modular solid-state oscillators, one of which is voltage-tuned. It provides swept or single-frequency output from 10 MHz to 1000 MHz by heterodyning (mixing) the output of the two oscillators. It provides swept or single-frequency output from 1 GHz - 2 GHz from the fundamental output of the voltage-tuned oscillator. The Model 650-10 and all other Model 650 Series plug-in units can be operated interchangeably in any Model 650, and no adjustments are required, either on the Model 650 or the plug-in unit, when interchanging plug-in units. Thus, by using several plug-in units interchangeably, full coverage up to 40 GHz can be provided beyond the Model 650-10 range of 10 MHz - 2 GHz. This provides a versatile, wide-range oscillator capability at minimum expense, and operation can be extended into additional bands when desired by purchasing additional plug-in units.

The Model 650-10 plug-in unit is equipped with an internal leveler-amplifier and an internal sampler to permit self-contained leveling. It can also provide leveled rf output when used with an external sampler. These units have a front panel RF SAMPLER INT-EXT switch to select either internal or external sampling.

The plug-in unit chassis is fabricated from aluminum. The top and bottom panels of the plug-in unit completely enclose the unit for shielding and mechanical protection. A power supply is contained in the rear of the plug-in unit. PC cards for power supply regulation, VTO frequency response shaping, and rf output leveling are mounted in the center section. The front of the plug-in unit is divided into a top and bottom compartment. The two oscillators, one band-switching relay, the PIN leveler, and the mixer are mounted in the top front compartment. The other band-switching relay, low-pass filter, and samplers for each band are mounted in the bottom front compartment.

The frequency dial plate providing dual scales for the 10 MHz - 1000 MHz and 1 - 2 GHz rf output bands of this plug-in unit is stored in the top cover storage compartment of the plug-in unit, as shown in Figure 2-1 of the Model 650 Instruction Manual. Installation of this plate onto the dial plate area of the Model 650 calibrates the Model 650 for operation with the Model 650-10 plug-in unit.

1.3 OTHER DOCUMENTATION FURNISHED WITH MANUAL.

An envelope at the rear of this manual contains factory performance-test data for the plug-in unit, as follows:

- a. "ADDENDUM A" listing instrument model and serial number of the instrument and the particular values of factory-selected components used.
- b. A maximum power output performance plot of the plug-in unit in each of the two bands, made during final swept-frequency testing at ALFRED.
- c. A plot similar to b for each of the two bands but showing performance in the leveled condition.

SECTION 2

INITIAL INSTRUCTIONS

2.1 GENERAL. Refer to Section 2 of the Model 650 Instruction Manual.

CAUTION

Solid-state oscillators are delicate. Handle the plug-in unit with care.

SECTION 3

OPERATING INSTRUCTIONS

3.1 REMOVAL, INSTALLATION, AND INTERCHANGING OF PLUG-IN UNITS IN THE MODEL 650.

CAUTION

When changing Plug-in units, turn the POWER switch off and wait 15 seconds before removing the installed Plug-in unit and inserting the other Plug-in unit, to permit decay of the power supply voltages. Then carry out the standard turn-on procedure.

3.1.1 REMOVAL OF A PLUG-IN UNIT FROM THE MODEL 650. To remove a plug-in unit from the Model 650, release its panel LOCK knob by turning fully CCW, and then pull the unit out of the Model 650 by pulling on the LOCK knob. Remove the frequency dial plate for that plug-in unit from the Model 650 panel and attach to the underside of the storage compartment door in the top of the plug-in unit, using the knurled screws removed with the plate. (See Figure 2-1 of the Model 650 Instruction Manual.)

3.1.2 INSTALLATION OF A PLUG-IN UNIT IN THE MODEL 650. To install a plug-in unit in the Model 650, first remove the frequency dial plate from the storage compartment door of that plug-in unit and install it into the calibrated position on the Model 650 panel. (See Paragraph 2.6 and Figures 2-1 and 3-1 of the Model 650 Instruction Manual.) Make sure the plug-in unit LOCK knob is turned fully CCW so the lock arm will clear the Model 650 panel opening and will enter far enough to actuate the safety interlock switch. The insert the plug-in unit through the Model 650 panel and lock in position by pushing in on the LOCK knob and turning it fully CW.

3.1.3 INTERCHANGING PLUG-IN UNITS IN THE MODEL 650. To interchange plug-in units, follow the procedure of Paragraphs 3.1.1 and 3.1.2 above. The Model 650 is properly calibrated for operation with the new plug-in unit by installation of the frequency dial plate for that unit. No adjustments are required.

3.2 FUNCTIONS OF PANEL CONTROLS, INDICATORS, AND CONNECTORS

See table 3-1.

Table 3-1. Functions of Model 650-10 Panel Controls, Indicators, and Connectors.

ITEM	FUNCTION
FREQUENCY Band Selector switch	Controls whether the rf output signal frequency band is .01 - 1 GHz or 1 - 2 GHz. When this switch is in the .01 - 1 GHz position, the rf output covers all or any portion of the 990 MHz band between 10 MHz and 1000 MHz, in accordance with the Model 650 FREQUENCY control settings on the corresponding dial scale. When this switch is in the 1 - 2 GHz position, the rf output covers all or any portion of the 1 - 2 GHz octave, in accordance with the Model 650 FREQUENCY control settings on the corresponding dial scale.
RF OUTPUT LEVELED/UNLEVELED Selector Switch	Controls whether the rf output signal is leveled (i.e. provides constant power across the band) or unleveled. In the LEVELED position, power output is at least 5 mw across the .01 - 1 GHz band and 50 mw across the 1 - 2 GHz band, and a power control range of >15 db is provided by the concentric POWER LEVEL control. In the UNLEVELED position, power output is not flat across each band, but varies due to the natural output characteristics of the oscillators used. Maximum power in each band is about 5 db greater than provided in the leveled mode, and a power control range of >20 db is provided by the concentric POWER LEVEL control.
POWER LEVEL Control (red knob concentric with LEVELED/UNLEVELED switch)	Adjusts the rf power output level in all modes of operation. Provides maximum power output when turned fully clockwise (CW). Provides minimum power output when turned fully counter-clockwise (CCW). Normally, there is a control range of >20 db between the CCW and CW limits of rotation. In the unleveled mode, this full range is available for power control. In the leveled mode, the UNLEVELED WHEN LIT light indicates when the power level is set too high for proper leveling. When the POWER LEVEL control is turned away from the CW limit to about its mid-position, the UNLEVELED light will extinguish, indicating that power output is leveled. The remaining control rotation, between this "point of maximum leveled power output" and the minimum-power CCW limit, provides a control range of >15 db for leveled power.

Table 3-1. Functions of Model 650-10 Panel Controls, Indicators, and Connectors (Con'd)

FILTER 3-position toggle switch	Controls the type of conditioning applied to the oscillator power and control signals within the plug-in unit to fit the selected operating mode. In the CW position, provides maximum filtering to improve the stability and purity of the single-frequency output signal. (Filtering is applied to both the oscillator power and frequency control signals.) In the SWEEP position (when the switch handle is in the center), provides no filtering so as not to interfere with swept oscillator operation. NOTE: When the Model 650 Function Selector is in either SWEEP position ($F_1 \rightarrow F_2$ or $F_0 \pm \Delta F$), or when external programmed sweep or FM modulation is used, the FILTER switch must be in the SWEEP position for proper performance. All amplitude modulation modes can also be used with the FILTER switch in the SWEEP position. In the CW MODULATED position, provides limited filtering to maintain a stable single frequency signal but allow it to be amplitude modulated. NOTE: When the Model 650 is set for amplitude modulation, i.e. when the MODULATION switch is not in the AM OFF position, the FILTER switch must be in the CW MODULATED position unless it has been placed in the SWEEP position.
UNLEVELED WHEN LIT lamp	In the leveled operating mode, glows as a warning when the rf output is not leveled over the band being swept. This condition may be caused by the POWER LEVEL control being set too high, the FILTER switch being in the wrong position, or an improper RF SAMPLER switch setting (or external sampler connections, if used). Glows continually in the unleveled operating mode.
RF SAMPLER Snap Switch	Selects INTERNAL or EXTERNAL rf power sampling for the leveled operating mode. For EXTERNAL sampling, the input from the external detector must be applied to the RF SAMPLER INPUT connector.
RF SAMPLER SENS. Screwdriver control	When using an external rf leveling sampler this control permits adjustment of the internal leveling amplifier sensitivity to match the external sampler output for optimum broadband leveling.
AM EXT Connector (type BNC)	Permits input of an external signal to amplitude-modulate the rf output, when the Model 650 MODULATION Selector switch is in the AM EXT position and the MODEL 650-10 FILTER switch is in the SWEEP or CW MODULATED positions. In the AM EXT modulation mode, the rf output will be turned off until an external modulation signal is applied. A +10 V signal will turn on the rf output to the set level in leveled or unleveled operation. Modulation response of the Model 650-10 is $\approx 25 \mu s$ for full-range on-off.
RF SAMPLER INPUT Connector (type BNC)	Permits connection of a signal from an external sensing coupler and detector to drive the leveling circuits. A detector input of approximately -100 mv, corresponding to rated rf power output, is required for optimum performance. Input impedance is 2800 ohms.
RF OUTPUT Connector (type N)	Supplies the Sweep Oscillator output signal.

3.3 OPERATING PROCEDURES.

Section 3 of the Model 650 Instruction Manual includes detailed instructions for operation of the plug-in unit. The paragraphs which follow in this 650-10 manual are intended to supplement the instructions contained in the same-numbered paragraphs of the Model 650 Instruction Manual.

3.4 INSTRUMENT TURN-ON PROCEDURE.

See paragraph 3.4 of the Model 650 Instruction Manual.

3.5 OPERATING PROCEDURES FOR SWEEP-FREQUENCY OUTPUT MODES.

On the Model 650-10 plug-in unit, switch the FREQUENCY switch to the desired band (.01 - 1 GHz or 1 - 2 GHz), and switch the FILTER switch to the SWEEP (middle) position. Then follow the instructions of paragraph 3.5 of the Model 650 Instruction Manual for the particular swept mode desired.

3.6 OPERATING PROCEDURES FOR SINGLE-FREQUENCY OUTPUT MODE.

On the Model 650-10 plug-in unit, switch the FREQUENCY switch to the desired band (.01 - 1 GHz or 1 - 2 GHz). Switch the FILTER switch to the CW (left) position unless amplitude modulation is to be used. If amplitude modulation is to be used (including square wave modulation), switch the FILTER switch to the CW MODULATED position. Then follow the instructions of paragraph 3.6 of the Model 650 Instruction Manual for single frequency operation.

3.7 SELECTION OF SWEEP TIME.

See paragraph 3.7 of the Model 650 Instruction Manual.

3.8 SELECTION OF SWEEP TRIGGER MODE.

See paragraph 3.8 of the Model 650 Instruction Manual.

3.9 MODULATING THE RF OUTPUT.

On the Model 650-10 plug-in unit, set the FILTER switch as follows:

- a. For AM modulation with single-frequency operation: CW MODULATED
- b. For AM modulation with swept frequency operation: SWEEP
- c. For FM modulation in any operating mode, with or without simultaneous AM: SWEEP

See paragraph 3.9 of the Model 650 Instruction Manual for additional general information.

3.10 AMPLITUDE MODULATION.

With the Model 650-10 plug-in unit, both internal and external amplitude modulation are available. The FILTER switch must be set in accordance with paragraph 3.9 above. The rise and fall time is about 25 μ s. Because of the finite response time of the solid-state circuits involved, high-speed pulsed rf modulation is not available in the Model 650-10, and the pulse drive signal to the AM EXT connector need not exceed 10 V.

Follow the instructions of paragraph 3.10 of the Model 650 Instruction Manual for the particular type of amplitude modulation desired.

3.11 FREQUENCY MODULATION.

With the Model 650-10 plug-in unit, both voltage-controlled FM and remote frequency programming are available. The FILTER switch must be in the SWEEP position for application of voltage-controlled FM, for remote-controlled sweeping, and for rapid-changing remote programming. For remote programming of single frequencies, the FILTER switch may be left in the CW position. Remote frequency stabilizing and high frequency FM using the FREQUENCY STABILIZING jack are not available since this jack is provided only on plug-in units having BWO tubes.

Follow the instructions of paragraph 3.11 of the Model 650 Instruction Manual for the particular type of frequency modulation desired.

3.12 RF OUTPUT LEVELING AND POWER LEVEL ADJUSTMENT.

The Model 650-10 provides leveling with internal or external sampling. Follow the instructions of paragraph 3.12 of the Model 650 Instruction Manual which are applicable to CK series plug-in units.

3.13 USE OF MARKERS.

The Model 650-10 provides internal rf markers or external video markers. The FILTER switch must be in the SWEEP position (as required anyway for swept operation) when markers are used. Follow the instructions of paragraph 3.13 of the Model 650 Instruction Manual for the type of markers desired.

3.14 RF OUTPUT BLANKING DURING SWEEP RETRACE.

See paragraph 3.14 of the Model 650 Instruction manual.

3.15 AUXILIARY OUTPUT SIGNALS.

See paragraph 3.15 of the Model 650 Instruction manual.

3.16 REMOTE CONTROL AND PROGRAMMING.

On the Model 650-10 plug-in unit, set the FILTER switch as follows:

- a. For frequency programming, use the SWEEP position for programmed sweeps or rapidly-selected single frequencies. Use the CW position only for external programming of single frequencies which are not changed rapidly.
- b. For amplitude programming, use the SWEEP or CW MODULATION positions for swept or single-frequency output, respectively.
- c. For power level programming, use the SWEEP or CW positions for swept or single frequency output, respectively.
- d. For sweep recurrence programming, use the SWEEP position.

Then follow the instructions of paragraph 3.16 of the Model 650 Instruction Manual for the particular type of programming desired.

3.17 APPLICATIONS INFORMATION.

The Model 650-10 extends down to 10 MHz the versatility of the Model 650 Series and the fast, simple swept testing techniques it makes possible. Refer to paragraph 3.17 of the Model 650 Instruction Manual for detailed applications information.

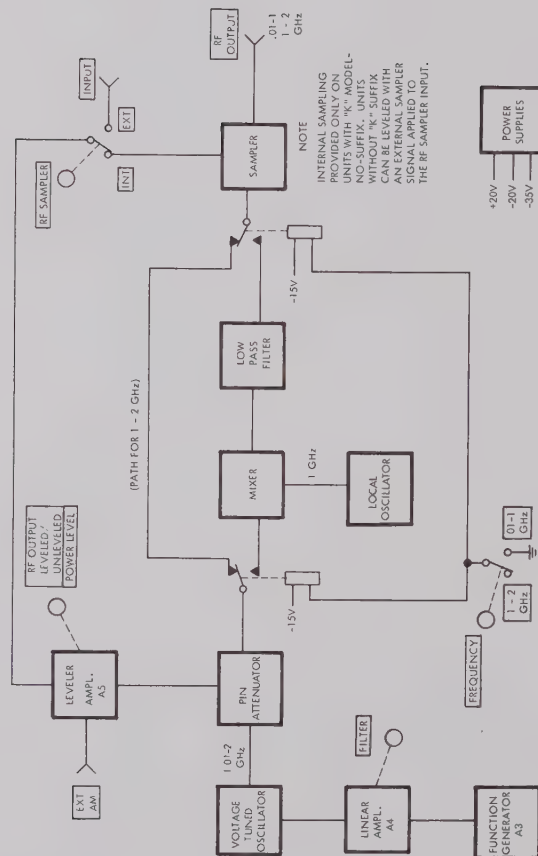


FIGURE 4-1. MODEL 650-10 BLOCK DIAGRAM

SECTION 4
CIRCUIT DESCRIPTION4.1 GENERAL BLOCK DIAGRAM DESCRIPTION
(See Figure 4-1.)

The Model 650-10 provides wide-band rf coverage by using a different operating mode for each of two bands. It generates a 1.0 to 2.0 GHz rf sweep directly using a voltage-tuned oscillator, and generates a second rf sweep range of 0.01 to 1.0 GHz by heterodyning the same 1.01 to 2.0 GHz signal with a 1 GHz fixed frequency. All the sweep, modulation and tuning functions of the Model 650 mainframe are retained. A block diagram of the Model 650-10 is shown in Figure 4-1.

In the 0.01 to 1.0 GHz band, the 1 to 2 GHz output of the voltage-tuned oscillator (VTO) is fed through the PIN attenuator to one input of the balanced mixer, and the output of the 1 GHz fixed oscillator (LO) is applied to the other mixer input. The difference frequency output of the mixer (≤ 1.0 GHz) is passed by the low-pass filter and applied through a wide-band sampler (directional detector) to the rf output terminal. (The sampler is included only in instruments with a "K" Model number prefix).

In both bands, the sampler provides a dc output, proportional to the rf output level, that is used to control the rf output power level during LEVELED operation (for units with "K" Model number prefix). The A5 Leveler-Amplifier circuit compares this dc voltage with a dc reference and controls the bias of the PIN attenuator to regulate the VTO output power to maintain constant rf level at the output terminal. Front-panel control of power level is accomplished by varying the Leveler-Amplifier dc reference voltage. During UNLEVELED operation, front-panel control of rf power is achieved by direct control of the PIN attenuator bias.

The frequency, blanking and amplitude modulation control signals produced by the Model 650 mainframe are applied to the Model 650-10 plug-in unit to control the frequency and modulate the power output of the VTO. The A3 Function Generator, A4 Linear Power Amplifier, and A25 HV Feedback circuits in the Model 650-10 provide signal conditioning and shaping of the frequency and modulation control signals applied to the VTO. The Function Generator circuit also produces the necessary -12V dc to operate the PIN attenuator.

The A2 Power Supply Regulator circuits produce the required dc voltages by regulating the dc outputs provided by the A1 Power Supply circuits. Supply voltages produced by the Model 650 mainframe are also used directly within the Model 650-10.

4.2 DETAILED THEORY OF A3 FUNCTION GENERATOR ASSY. (See Schematic 907368).

4.2.1 GENERAL. The Function Generator provides the basic interface between the Model 650 mainframe and the Model 650-10 rf plug-in unit. Three separate "functions" are performed to provide this interface:

- a. Develop the frequency control signal for the VTO by shaping a low-voltage replica of the high voltage cathode supply ramp from the mainframe. The cathode supply voltage, as a function of time, is established by the Model 650 FREQUENCY and SWEEP controls and may be either a fixed voltage or a ramp. Since the cathode supply voltage is suitable for driving high voltage BWO tubes, its minimum level of -150V must be reduced for

application to the solid-state VTO. Therefore the low voltage output of HV Feedback Assy. A25 is used not only for closing the feedback loop to the frequency control circuits in the Model 650 mainframe but also for driving the shaping circuits in Function Generator Assy. A3 for frequency control of the VTO. The A3 Assy. also provides a 0 to -15V feedback signal to the mainframe cathode supply to provide closed-loop control of cathode supply output voltage over a range which is linear with frequency. This feedback replaces that provided by Diode Shaper Assy. A13 in non-solid-state units.

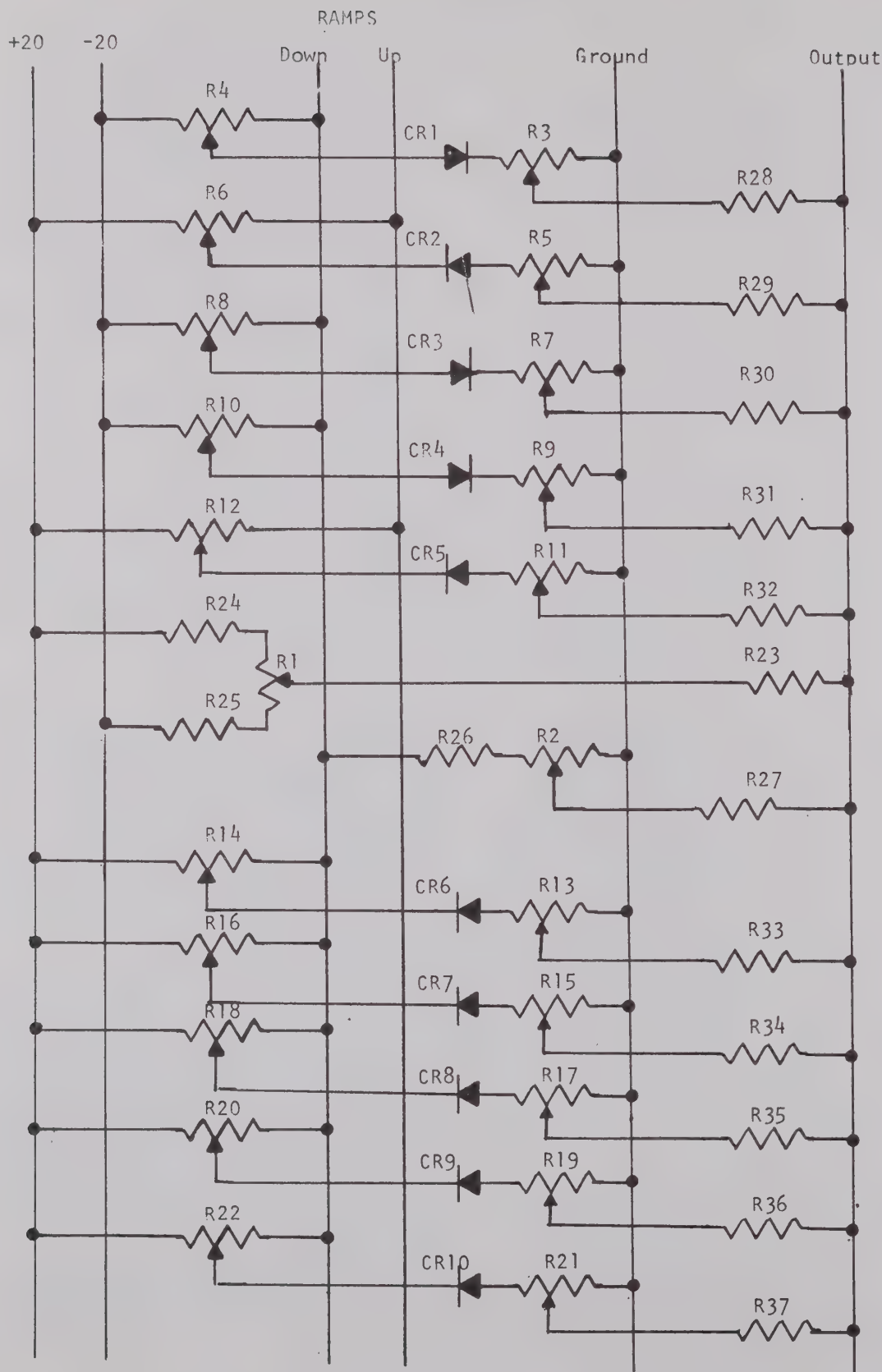
- b. Develops the retrace blanking, frequency markers and square-wave modulation control signals for the VTO by shaping the "Leveler-Amplifier reference" signal supplied by the mainframe Modulator Assy. at A5 pin R in the mainframe.
- c. Develops -12V dc operating voltage for the PIN attenuator by regulating the -20V dc output from the Regulator Assy. A2.

4.2.2 VTO FREQUENCY CONTROL SIGNAL. The frequency control signal (tuning ramp) for the VTO is developed by converting the ≈ 0 to -15V attenuated cathode supply voltage at A3 pin E (supplied by A25) into down-and up-ramp voltages at A3 pin S and A3 pin Z, respectively. These two ramps are combined in Linear Amplifier A4 to provide a single tuning voltage input to the VTO. In addition to producing both a negative- and positive- going ramp, the A3 Assy. also develops feedback to complete the control loop for the cathode supply in the mainframe.

The attenuated cathode supply voltage at A3 pin C is isolated and impedance-converted by cascaded emitter follower amplifier stages A3Q1 and A3Q2. Bleeder resistor A3R1 taps a small (+) input from the +15V supply to offset the low-band-edge (-) input at A3 pin C. (This residual (-) input exists because the cathode supply output drops only to -750V, not 0V, before attenuation at low-band-edge.) This adjusts the emitter follower output to a range of 0 to -15V, which is applied back to the summing junction of the Cathode Supply circuit of the mainframe via A3 pin A to achieve a cathode supply excursion of -750 to -1500V which is essentially linear with frequency. Resistor A3R2 and diodes A3CR1 - A3CR3 provide a fixed collector bias of ≈ 1.8 V for A3Q1 and A3Q2.

The 0 to -15V signal developed at A3 pin A by A3Q1 and A3Q2 is also applied to Operational Amplifier A3AR1 through voltage divider A3R5 and A3R6. Down Ramp Amplitude control A3R6 permits adjustment of the amplitude of the op amp input to obtain the desired 10V output amplitude for both ramps. Voltage divider A3R9, A3R11, and Down Ramp Balance control A3R10 applies proper dc bias to the other input of A3AR1 to obtain the desired ramp symmetry about a zero-volt dc reference. Since the 0 to -15V input is applied to the "non-inverting" input of the operational amplifier, the output signal is a +5V to -5V "down" tuning ramp. Stage gain is determined by feedback resistor A3R12; A3C3 provides frequency compensation.

The +5V to -5V ramp output from A3AR1 is applied to the "inverting" input of an identical operational amplifier A3AR2. Voltage divider A3R15, A3R17, and Up Ramp Balance control



A3R16 applies proper dc bias to the other input of A3AR2 to obtain the desired ramp symmetry about a zero-volt dc reference. The output of A3AR2 is a -5V to +5V "up" ramp. Both the "down" ramp from A3AR1 and the "up" ramp from A3AR2 are further shaped and combined by the Linear Power Amplifier Assy. A4 for application to the VTO as the "sweep" or frequency-control signal (see paragraph 4.3).

4.2.3 VTO AMPLITUDE CONTROL SIGNAL. The VTO "bias" or amplitude control signal for "full-off" modulation in retrace blanking or square-wave modulation modes is developed from the 0 to -5V "Leveler-Amplifier reference" amplitude modulation signal produced by the main frame Modulator Assy. and applied via P6 to A3 pin T. This signal controls the conduction of A3Q5 so that it is turned on (by -5V base input) when the VTO is to be "on". A3Q5 is turned off (by 0V base input) when the VTO is to be cut off for retrace "off" or square-wave modulation "off" intervals. To prevent the A5 Leveler-Amplifier from trying to correct for this desired "full off" modulation, a 0 to ∞ -0.5V leveler reference signal from voltage divider A3R20/A3R21 in the A3Q5 emitter follower circuit, is provided for application to A5 in the leveled mode via A3 pin U, S2, and the POWER LEVEL control.

When A3Q5 is turned on by -5V at its base, the negative reference voltage feedback for the Leveler-Amplifier is developed by A3R21, and A3Q4 is forward biased. The conduction of A3Q4 holds the junction of A3R26 and A3R28 at effectively zero volts. Since A3Q6 is held on by its fixed bias, the bottom of A3R29 is also held at zero volts and no base bias is applied to A3Q3 keeping it cut off. With A3Q3 turned off, the blanking output line at A3 pin E is held at the -35V collector potential applied from A4R56 in the Linear Power Amplifier via A4 pin E.

When a blanking pulse is applied to A3 pin T from the main-frame, A3Q5 will be cutoff with its base held at -5V. As a result, A3Q4 will also be cut off and the junction of A3R26 and A3R28 will drop toward -20V. This develops negative base bias which will turn A3Q3 on to saturation. The reference voltage output at A3 pin U and the blanking output line at A3 pin E will both be held at zero volts. The A3 pin E blanking output line controls application of operating "bias" power to the VTO by Linear Power Amplifier A4. Power drive to the VTO is inhibited when A3 pin E is at -35V.

4.2.4 -12V POWER SUPPLY/REGULATOR CIRCUIT. The -12V dc operating voltage for the PIN attenuator is developed by regulating the -20V dc output from Regulator Assy. A2. Regulation is accomplished by comparing a sample of the -12V dc output to a fixed reference, in this case, zero volts.

Series Regulator A3Q9 is driven by Regulator Driver A3Q10, which is controlled by the conduction of Differential Amplifier A3Q7/A3Q8. If, for example, the -12V dc output attempts to increase (go more negative), the output sample developed by A3R34, A3R35 and A3R36 will also become more negative, thus increasing the forward bias of A3Q7. The increased conduction of Q7 will decrease the base drive to A3Q10 which will decrease the base drive to Q9. The reduced conduction of Q9 will prevent any increase in the -12V dc output.

4.3 DETAILED THEORY OF A4 LINEAR POWER AMPLIFIER
(See Schematic 907371).

The Linear Power Amplifier provides the final shaping and impedance conversion of the VTO frequency and amplitude

control signals. Tuning ramp shaping is accomplished by summing selected contributions from both the down and up ramp inputs at A4 pin B and A4, pin Z at various points along the ramp excursion. The result of the ramp summing, performed by the shunt diode network shown in Figure 4-2, is a non-linear tuning ramp. This non-linear tuning signal compensates for the inherent non-linear tuning characteristic of the VTO and results in an overall linear frequency tuning response.

The down - (+5V to -5V) and up - (-5V to +5V) ramp signals, from the Function Generator, are simultaneously applied to the diode shaping network A4CR1 through A4CR10. Even-numbered resistors A4R4 through A4R22 may be connected to either the up or down ramp to drive the diodes. The other fixed terminal of R4 through A4R22 may be connected to either +20V or -20V. This plus the fact that the wiper tap on each can be set at any position, provides extreme flexibility in arranging the points of zero crossover on the wipers of even-numbered resistor A4R4 thru A4R22 versus the instantaneous position of the input up and down ramps.

Since diodes A4CR1 through A4CR10 can be installed with either polarity, the diodes will be either turned on or cut off within $\pm 0.6V$ of the zero crossover point, depending on polarity. Thus each diode in the shaping network can be set up to either add current to or subtract current from summing resistor A4R38, beginning or ending at each individual zero crossover point during the excursion of the two sweep ramps. The current increment controlled by each diode is also adjustable by means of odd-numbered resistors A4R3 - A4R21. Figure 4-3 shows an example shaped tuning signal and how each diode section contributes to the overall non-linear curve. In addition, voltage divider A4R1, A4R24, and A4R25 can be set to supply any required fixed offset current to summing resistor A4R38, and voltage divider A4R2 and A4R26 can be set to supply any required amount of direct linear drive current from either ramp to summing resistor A4R38. The shaper circuit thus provides extreme flexibility in accommodating any required VTO characteristic.

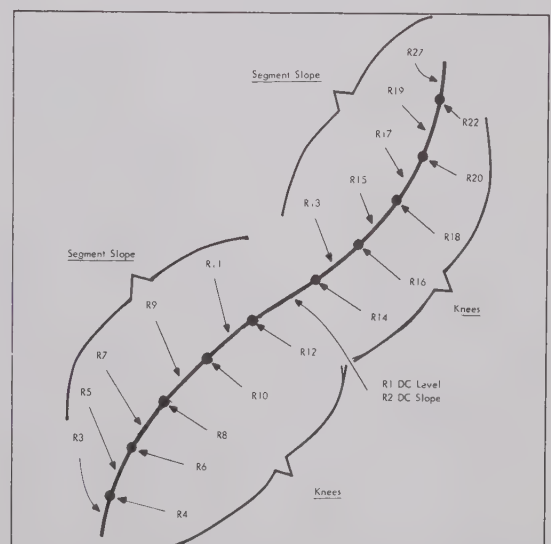


FIGURE 4-3. EXAMPLE SHAPED TUNING CURVE

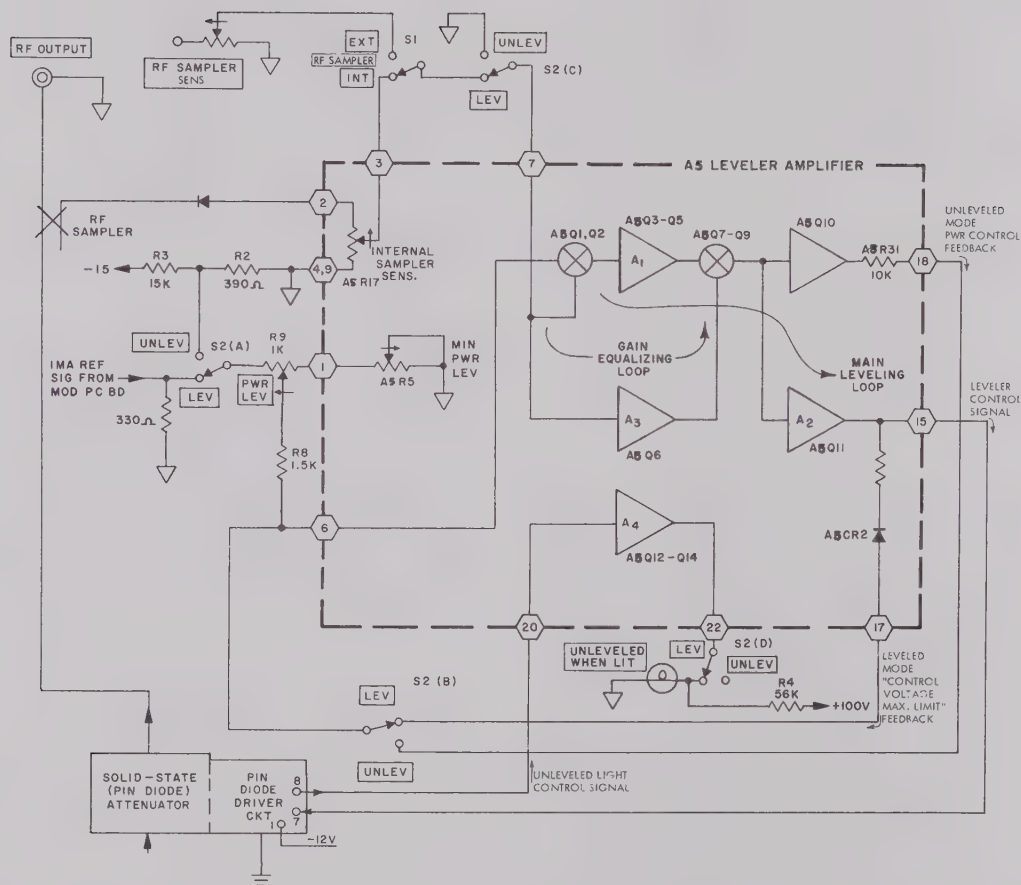


FIGURE 4-4. SIMPLIFIED DIAGRAM OF RF OUTPUT AND LEVEL CONTROL CIRCUITS

As the input ramps drive the wipers of even-numbered resistors A4R4 thru A4R22 to the different zero crossover points set up for each of the shaping diodes, different amounts of negative and positive current, related to the values of A4R28 - A4R37 and the adjustment of odd-numbered resistors A4R3 - A4R21, are summed with the linear down-ramp current applied through A4R27, thus producing the required non-linear ramp at the #2 input terminal of Operational Amplifier A4AR1. The shaped tuning signal is amplified and inverted by op amp A4AR1 and applied to Complementary Emitter Followers A4Q1 and A4Q2. Operational amplifier gain is determined by feedback network A4R39, A4R40 and A9R41. The complementary emitter followers and subsequent stages are analogous to a class A push-pull driver circuit. Quiescent operating bias for the input transistors A4Q1 and A4Q2 is developed across voltage divider A4R42, A4CR11, A4CR12, A4R45, and A4R44 between +100V and -50V. With 0V output from A4AR1 the values established for A4R44 and A4R42 cause A4Q2 to be more heavily forward biased than A4Q1. A4Q4 and A4Q6 are thus turned on to heavier conduction than A4Q3 and A4Q5, with the result that the junction of A4R53 and A4R55 is held at approximately 0V. (It differs from 0V by the drop across A4R55 due to the VTO tuning current drawn when the required 0V is established at A4 pin S). As the sweep progresses above low-band-edge, the forward bias on A4Q1 is slightly increased, and that on A4Q2 is slightly decreased. This complementary effect also increases the conduction of A4Q3 and A4Q5, and decreases the conduction of A4Q4 and A4Q6, with the result that the output, at the junction of A4R53 and A4R55 is raised toward +100V. The feedback network for the output voltage, A4R39 - A4R41 permits output control over the full range of approximately 0 to +50V used by most VTO's, with an A4AR1 op amp output level of less than a volt. Through proper set-up of the diode shaper network, the tuning voltage can be shaped and controlled over the full -50V to +100V range provided by the mainframe supplies. The shaping and amplifier circuits have the capability of driving a VTO requiring either polarity of signal change for frequency increase, and requiring any zero or non-zero band-edge starting voltage.

When the FILTER switch S1 is in either of its CW positions it grounds A4 pin P so that capacitor A4C3 filters the VTO tuning voltage for stable frequency performance. A4 pin P is open-circuited to disable A4C3 when S1 is in the SWEEP position. Final impedance conversion of the VTO amplitude control signal is provided by Darlington pair A4Q7 and A4Q8. When no blanking or other modulation is present, A4 pin E is grounded and the Darlington pair is cut off, removing drive power from the VTO.

When internal markers are generated, the amplitude modulation control signal applied to A3 pin T from the mainframe carries the marker pulses, and they are coupled to the A5 Leveler-Amplifier and the PIN attenuator via the reference amplitude output provided at A3 pin U. The markers produce absorption pips in the rf output by pulsing the PIN attenuator. Their effect on VTO power output through modulation of the A3 and A4 amplitude control circuits is superfluous in operation. In unleveled operation, however, the marker pulses are disconnected from the Leveler-Amplifier but still produce very narrow rf marker pips by momentarily blanking the VTO.

When FILTER switch S1 is in the CW position, it grounds A4 pin A so that capacitor A4C5 filters the control voltage applied to Darlington pair A4Q7 and A4Q8. This eliminates

any ripple in the amplitude control signal applied to the VTO for optimum stability. A4 pin A is open-circuited to disable A4C5 when S1 is in the SWEEP or CW MODULATED positions to enable application of "retrace off" and square wave modulation, respectively.

4.4 DETAILED THEORY OF A5 LEVELER-AMPLIFIER (See Figure 4-4 and Schematic 900933).

4.4.1 GENERAL. The Leveler-Amplifier provides the control signal for the PIN attenuator. The PIN attenuator controls the power output level of the VTO to hold the signal at the RF OUTPUT terminal constant. It does this by attenuating variable amounts of rf power, as necessary to maintain constant output across the band, while the VTO is allowed to operate at full power which, although not level across the band, is the ideal condition for optimum frequency accuracy. Application of variable-level amplitude control signals to the VTO would produce frequency pushing and degrade frequency accuracy. Use of amplitude modulation signals for full-off VTO modulation for retrace off or square wave modes does not produce significant frequency pushing because the output is turned completely off when the modulation is applied.

4.4.2 LEVELED OPERATION. The Leveler-Amplifier control signal output is developed by comparing a dc voltage, developed by the sampler (directional detector) and proportional to the rf output (applied at A5 pin 7), to a reference voltage that is determined by the POWER LEVEL control (applied at A5 pin 6). Any difference between the two signals is amplified by differential amplifiers A5Q1A/B, and A5Q3/A5Q4. The output of A5Q11 (at A5, pin 15) is applied to the PIN attenuator to control the rf output level. This output ranges from -2V (min. attenuation) to -0.5V (max. attenuation).

Whenever the sampler signal input increases (goes more negative) because of an attempted rf power increase (or because the POWER LEVEL control is adjusted to decrease the rf power), A5Q1A will conduct more than A5Q1B. As a result, A5Q3 will decrease conduction and A5Q4 will increase conduction. The decreased conduction of A5Q3 will cause A5Q5 to conduct less. Because the decreased conduction of A5Q5 will cause A5Q7 to decrease conduction, A5Q11 will increase conduction and the PIN attenuator control voltage go more negative. A more negative control voltage will increase the attenuation of the VTO output which will reduce the power at the RF OUTPUT terminal.

The dynamic range of the Leveler-Amplifier is extended by including a gain equalizing circuit that compensates for sampler crystal sensitivity variations and Leveler-Amplifier frequency response variations. The crystal sensitivity compensation is accomplished by differential amplifier A5Q6, which applies a bias, proportional to the sampler output magnitude, to one side of the differential amplifier A5Q7, and A5Q8. The equalizer bias thus changes the gain of the differential amplifier to reduce control signal amplification at high power levels, where crystal sensitivity (mV/dB) is high, and increase amplification at low power levels. Frequency response variations are compensated by A5C6 and A5R21, A5C7 and A5R27, and A5C8 and A5R26.

Since the base of A5Q6B is at zero volts, the negative-polarity sampler signal will cause A5Q6A to conduct less than A5Q6B. The difference in conduction is proportional to

the amplitude of the sampler signal. When the sampler signal becomes more negative because of a high power level setting, A5Q6B will conduct more than A5Q6A. The increased conduction of A5Q6B will cause A5Q8 to conduct more, thus reducing the amplification of the control voltage signal by differential amplifier A5Q7 and A5Q8.

4.4.3 UNLEVELED OPERATION. To provide power level adjustment in the UNLEVELED mode, the dc voltage developed by the RF OUTPUT control is amplified to allow direct control of the PIN attenuator over its full range (instead of comparing the rf output to a reference to derive the attenuator bias). The dc voltage amplification is provided by the Leveler-Amplifier circuit, with the necessary circuit changes made by the RF OUTPUT switch as shown in Figure 4-4.

Placing the RF OUTPUT switch in the UNLEVELED position performs the following:

- a. Disables the differential amplifier operation of the Leveler-Amplifier circuit by grounding the sampler input to differential amplifier A5Q1 and the input to the gain equalizing circuit A5Q6; and
- b. Converts the Leveler-Amplifier circuit to a dc operational amplifier by connecting the output of emitter follower A5Q10 back to the reference input. Operational amplifier gain is regulated by the feedback developed through resistor A5R31.

4.4.4 REFERENCE INPUT DETERMINATION. The reference voltage input to differential amplifier A5Q1 is determined by the voltage tapped from POWER LEVEL potentiometer R1. The voltage tapped from R1, however, is controlled by the following:

- a. The leveler reference output from the modulator section of the Function Generator Assy. A3;
- b. The control-voltage-maximum-limit feedback developed by A5CR2; and
- c. The control-voltage-minimum-limit feedback developed by A5CR1.

During blanking or negative half-cycles of square-wave modulation, the sampler input is reduced to zero volts. The Leveler-Amplifier might attempt to compensate for this power level drop by biasing the PIN Attenuator for minimum attenuation. However, since the Leveler-Amplifier reference output from the mainframe modulator is connected to the reference input through R1, the reference input is also reduced to zero. Thus, the Leveler-Amplifier remains balanced during the "full-off" modulation period rather than going into saturation by trying to compensate for the blanked rf output. When no modulation is present, the reference voltage developed by R1 can be varied between -300 mV and a minimum (0 to -60mV) set by A5R5 to provide a power level control range of 10 dB below maximum leveled power.

During the "full-off" modulation period when both inputs of the Leveler-Amplifier are at zero volts, the slight value difference between A5R1 and A5R2 ensures the PIN control voltage will be negative. The control-voltage-maximum-limit feedback developed by A5CR2 prevents the control voltage from going too negative and thus improves the response time of the Leveler-Amplifier when rf power turns back on.

When the RF OUTPUT switch is placed in the UNLEVELED position, the control-voltage-maximum-limit feedback developed by A5CR2 is removed and replaced by feedback from emitter follower A5Q10. The reference voltage input is determined by a fixed bias controlled by POWER LEVEL potentiometer R1.

4.4.5 OPERATION AT OUTPUT LEVELS ABOVE THE MAXIMUM LEVELED POINT (See Figure 4-5). When operating in the leveled mode, if the rf output power is adjusted to greater than maximum leveled power, the Leveler-Amplifier will attempt to reduce the PIN Attenuator control voltage below its minimum level when rf power drops below the output setting (see Figure 4-5). The control-voltage-minimum-limit feedback developed by A5CR1 will prevent Q7 from saturating when attempting to reduce PIN bias below its minimum. As a result, the Leveler-Amplifier response is improved to provide a smooth transition between leveled and unleveled portions of the sweep.

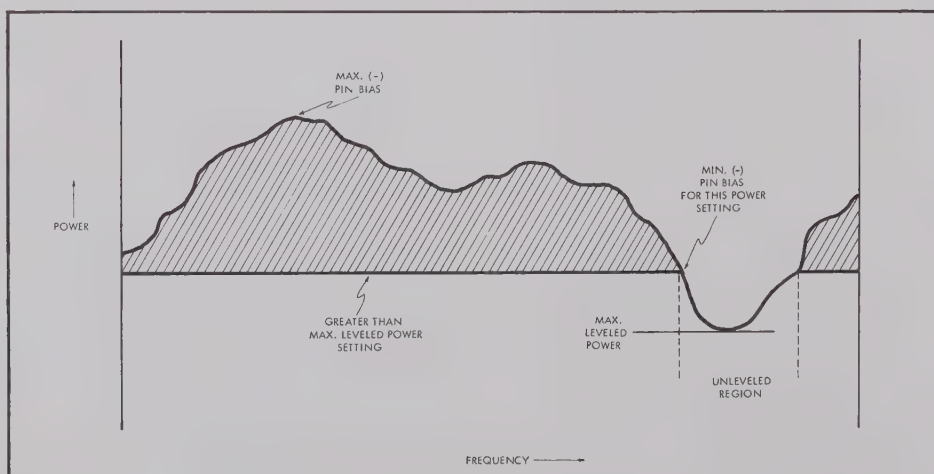


FIGURE 4-5. EFFECT OF SETTING OUTPUT TO GREATER THAN MAXIMUM LEVELED POWER.

4.4.6 UNLEVELED LIGHT OPERATION. The UNLEVELED WHEN LIT lamp indicates when the rf power is unleveled. During UNLEVELED operation, the indicator will be continually on. During LEVELED operation, the indicator will light if the rf power becomes unleveled during any portion of the sweep.

The +100V bias applied through chassis resistor R7 will hold the lamp on during UNLEVELED operation. In the LEVELED mode, however, the RF OUTPUT switch connects A5Q14 in parallel with the UNLEVELED lamp, causing the lamp to turn off. The conduction of A5Q14 is controlled by the unleveled sensing signal from the PIN attenuator.

When the rf power remains leveled during the entire sweep, the unleveled sensing signal will remain more negative than -3.75V. As a result, A5Q12 will be held cutoff and A5Q13 will be cutoff. With A5Q13 cutoff, the full +15V bias is applied to the base of A5Q14, causing it to conduct all available current past the UNLEVELED lamp, thus holding the lamp off.

If the rf power becomes unleveled during any portion of the sweep, the unleveled sensing signal from the PIN attenuator will become less negative than -3.75V. Therefore, A5Q12 will turn on, A5Q13 will turn on and the base of A5Q14 will no longer be forward biased. A5Q14 will turn off, allowing the +100V bias to turn on the UNLEVELED lamp to indicate unleveled rf power. The time constant of A5R47/A5C10 will hold A5Q14 off when rf power temporarily becomes unleveled. Only when the rf power remains leveled for the entire sweep will the UNLEVELED lamp remain off.

4.5 DETAILED THEORY OF POWER SUPPLIES (Assemblies A1 and A2; See Schematic 907397 and 907373).

4.5.1 +20 VOLT POWER SUPPLY & REGULATOR (See

Figure 4-6). The +20V power supply regulator within A2 uses the unregulated +24V power supply output from A1 to produce a highly stable +20V dc. The +24V is developed at A1 pin J by full-wave rectifier A1CR1, A1C1, A1C2, and A1R4. Voltage is supplied to A2 pin V and is regulated and controlled in A2 by comparing an output voltage sample (determined by the +20V ADJUST control A2R21) to a constant reference voltage (established by zener diode A2CR5). Whenever the regulated output voltage attempts to change, a difference output is developed and amplified by differential amplifiers A2Q14A/B, A2Q10/A2Q13, A2Q9/A2Q12, and A2Q8/A2Q11. The output of A2Q8 controls the conduction of the current control, A2Q6. The conduction of A2Q6 determines how much current drive is supplied to the regulator driver A2Q2, by the constant current source A2Q7. The regulator driver controls the conduction of the series regulator Q1, which controls the output voltage. The regulated +20V output is applied to A1 pin X for filtering by A1C3 and A1C6.

If, for example, the output voltage attempts to increase because of a load change, the increased sample developed across A2R20 thru A2R22 will cause A2Q14B to conduct more than A2Q14A. The increased conduction of A2Q14B will cause A2Q13 to conduct more than A2Q10, which will cause A2Q12 to conduct more than A2Q9. As a result, A2Q8 will conduct more than A2Q11, causing A2Q6 to increase conduction. Since more current will be supplied to A2Q6 by the constant

current source A2Q7, less current drive will be available for A2Q2. A2Q2 will, therefore, decrease conduction causing the series regulator Q1, to decrease conduction, preventing any increase in the +20V output.

Protective circuits are provided to prevent damage to the Model 650-10 circuitry in case of a circuit malfunction. Voltage limiter A2Q4 prevents any excessive increase in output voltage if the regulator malfunctions. Any uninhibited increase in output voltage increases the conduction of A2Q4 which draws current from the unregulated power supply, shunting the "regulated" output and preventing it from supplying too much current to connected components.

Current limiter A2Q3 prevents excess current from being drawn by a malfunctioning circuit connected to the regulator output. When excess current drain causes the voltage drop across A2R1 to forward bias A2Q3, the conduction of A2Q3 causes the voltage control A2Q5 to turn on very hard. The heavy conduction of A2Q5 causes the constant current A2Q7 to supply very little drive to A2Q2, which reduces the conduction of the series regulator and prevents any excess current drain on the supply.

4.5.2 -20 VOLT POWER SUPPLY REGULATOR (See

Figure 4-7). The -20V power supply regulator operation is similar to the operation of the +20V regulator. The highly stable -20V output is derived from the unregulated -24V power supply output. The -24V is also developed by A1CR1, A1C1, A1C2, and A1R4, and is supplied to A2 pin E via A1 pin U.

The regulated output is controlled by comparing a sample of the regulator output (from -20V ADJUST control A2R43) to a constant reference established by zener diode A2CR10. Any difference is amplified by differential amplifiers A2Q27A/B, A2Q23/A2Q26, A2Q22/A2Q25, and A2Q21/A2Q24. The output of A2Q24 controls the conduction of the current control A2Q18. The conduction of A2Q18 determines how much current drive is supplied to the regulator driver A2Q19, by the constant current source A2Q15. The regulator driver controls the conduction of the series regulator Q28, which controls the output voltage. The regulated -20V output is applied to A1 pin A for filtering by A1C4 and A1C7.

When the output voltage attempts to increase (go more negative), the increased sample across A2R42 thru A2R44 will cause A2Q27B to conduct less than A2Q27A. The decreased conduction of A2Q27B will cause A2Q26 to conduct less than A2Q23, which will cause A2Q25 to conduct less than A2Q22. As a result, A2Q24 will conduct more than A2Q21, causing A2Q18 to increase conduction. Since more current will be supplied to A2Q18 by the constant current source A2Q15, less current drive will be available for A2Q19. A2Q19 will, therefore, decrease conduction, causing the series regulator Q28 to decrease conduction and preventing any increase in the -20V output.

Protective circuits equivalent to those provided in +20V regulator are also included in the -20V regulator. Voltage limiter A2Q16 prevents any excessive increase in the regulator output if the regulator malfunctions. Any uninhibited increase in output voltage increases the conduction of A2Q16, which draws current from the unregulated power supply and prevents the regulator from supplying too much power to connected components.

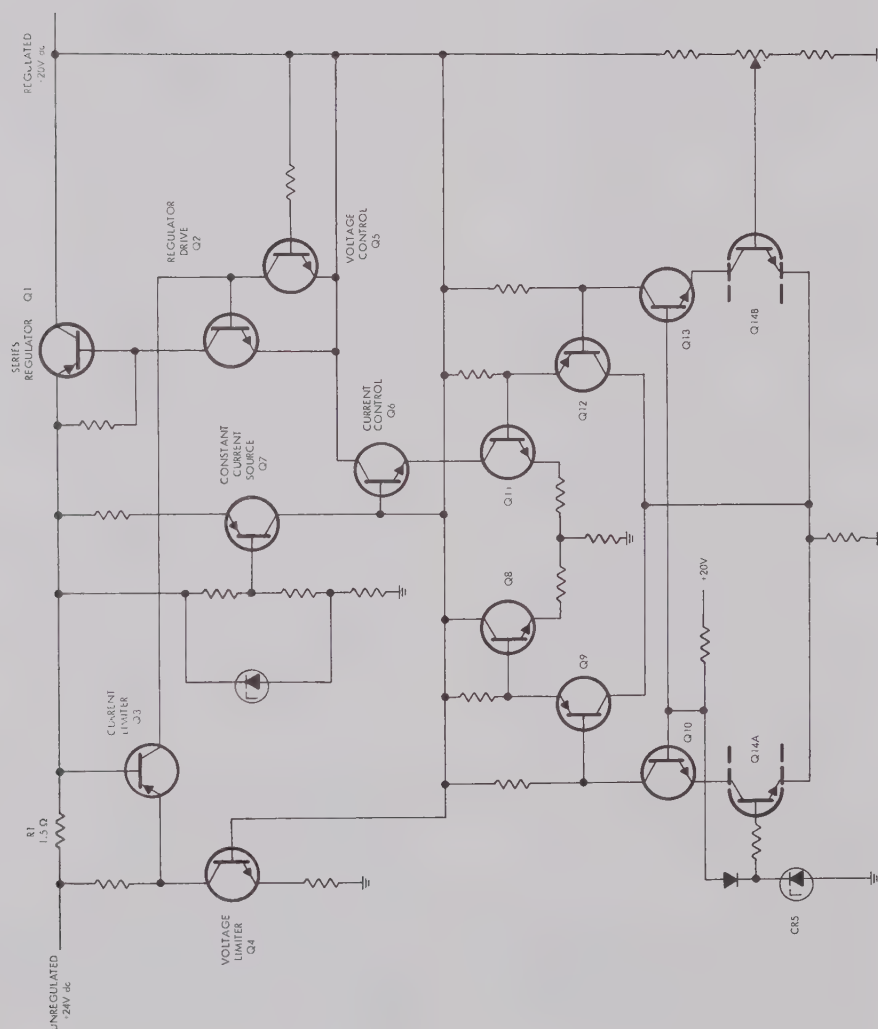


FIGURE 4-6. +20 Vdc REGULATOR

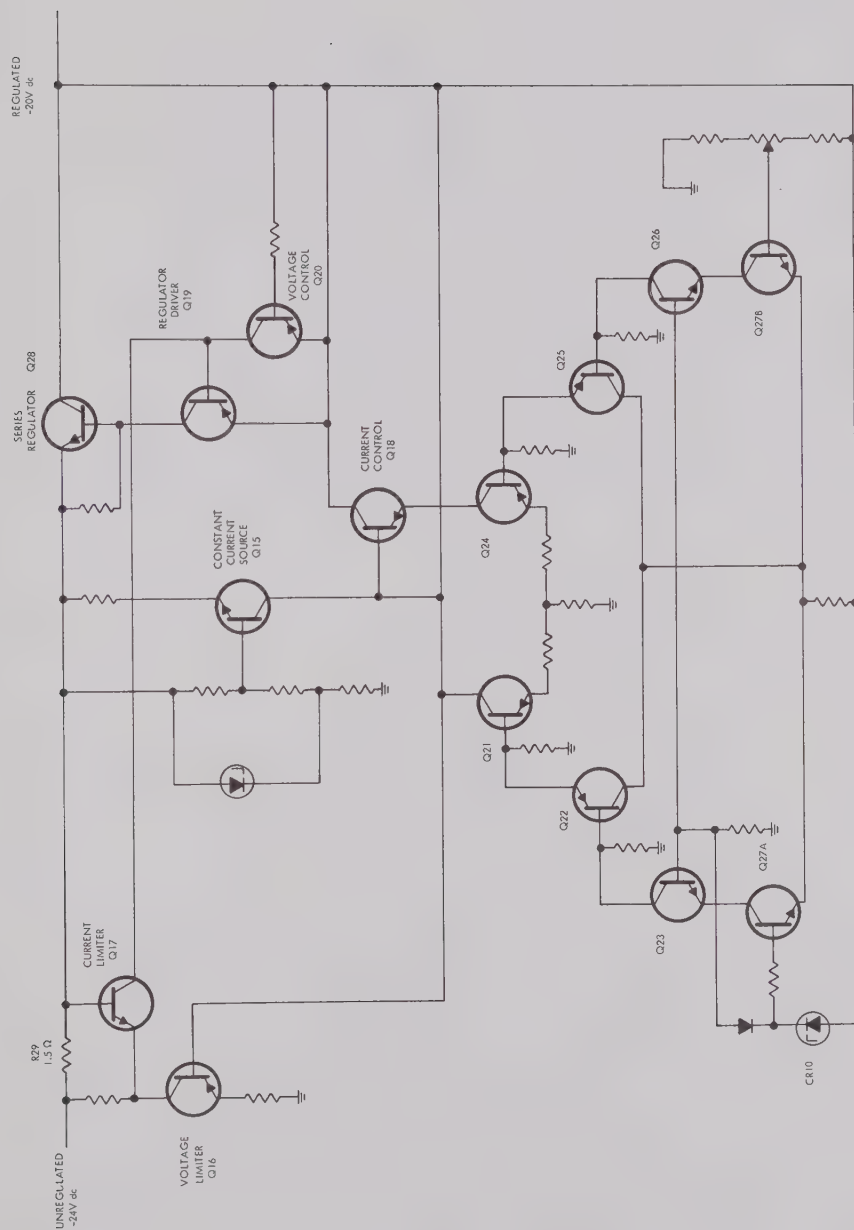


FIGURE 4-7. -20 Vdc REGULATOR

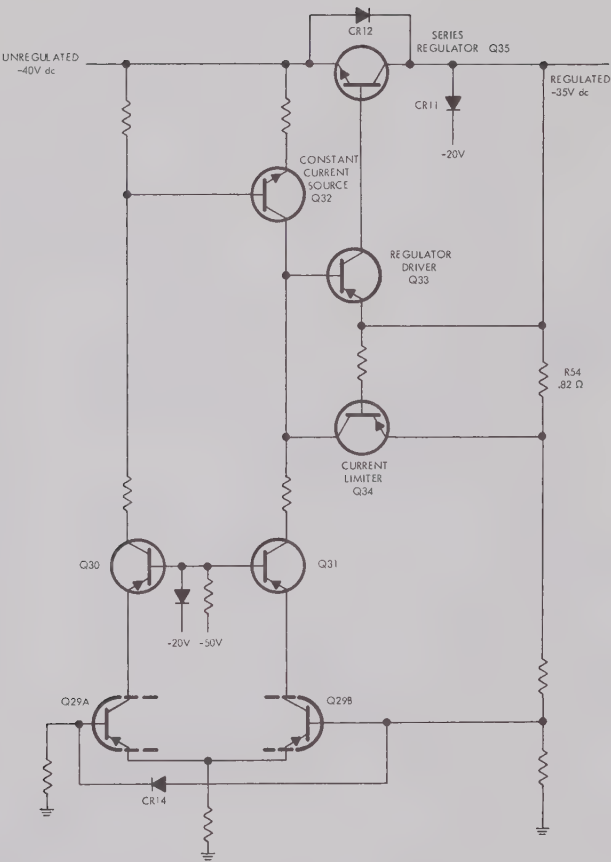


FIGURE 4-8. -35 Vdc REGULATOR

Current limiter A2Q17 prevents excess current from being drawn by a malfunctioning circuit connected to the regulator output. When excess current drain causes the voltage drop across A2R29 to forward bias A2Q17, the conduction of A2Q17 causes the voltage control A2Q20 to turn on very hard. The heavy conduction of A2Q20 causes the constant current source A2Q15 to supply very little drive to A2Q19, which reduces the conduction of the series regulator and prevents excess current drain on the supply.

4.5.3 -35 VOLT POWER SUPPLY REGULATOR

(See Figure 4-8). The -35V power supply regulator uses the unregulated -40V power supply output to produce a highly stable -35V dc. The unregulated -40V is developed at A1 pin H by A1CR2 and A1R5, and is applied to A2 pin A for regulation. The regulated output is controlled by comparing a sample of the regulated output (tapped from voltage divider A2R55 and A2R56) to a constant voltage reference tapped from the regulated -20V supply by A2R46. Any difference is amplified by differential amplifiers A2Q29A and B, and A2Q30/A2Q31. The output of A2Q31 determines how much current drive is supplied to the regulator driver A2Q33, by the constant current source A2Q32. The amount of current drive to A2Q33 determines the conduction of series regulator Q35, which determines the regulator output voltage.

If, for example, the regulator output attempts to increase (go more negative), the voltage sample developed by A2R55 and A2R56 will cause A2Q29B to conduct more than A2Q29A. The increased conduction of A2Q29B will

cause A2Q31 to conduct more than A2Q30. Since more current will be required by A2Q31, the constant current source A2Q32, will provide less current drive to the regulator driver A2Q33. The reduced drive to A2Q33 decreases its conduction, which will decrease the drive to the series regulator Q35. Q35 will conduct less, preventing any increase in the output voltage.

Protective circuits are included in the -35V regulator to prevent damage to Model 650-10 components in the event of a circuit malfunction. Current limiter A2Q34 prevents excess current from being drawn by a malfunctioning circuit connected to the regulator output. An excess current drain causes the voltage drop across A2R54 to forward bias A2Q34. The conduction of A2Q34 reduces the amount of current drive supplied to the regulator driver A2Q33, by the constant current source A2Q32. The reduced drive to A2Q32 reduces the conduction of the series regulator Q35 and prevents excess current drain on the supply.

In case of a regulator malfunction, diodes A2CR11, A2CR12 and A2CR14 will prevent damage caused by an uninhibited voltage change. If the output voltage becomes too negative, A2CR12 will be forward biased, to shunt and protect the series regulator Q35. If the output voltage becomes too positive, the regulator will be clamped at -20V by diode A2CR11, and differential amplifier A2Q29A and B will be protected by CR14 which will shunt an excess differential signal across its bases.

TABLE 5-1. REQUIRED TEST EQUIPMENT

<u>Test Equipment</u>	<u>Critical Specifications</u>	<u>Manufacturer and Model</u>
Network Analyzer and Sensor or Power Meter and Thermistor Mount	Freq. range: 10 Mhz - 2 GHz Accuracy: $\pm 2\%$ Power range: 100 μ W = 10 MW	Alfred Model 8000/7051 and Matched Detector or Model 1403 Low Freq. Compensation Network or HP Model 431C with 478A Thermistor Mount
Frequency Counter	Freq. range: 10 MHz - 2 GHz Accuracy: ± 1 digit Resolution: 4 digits	Sysdron - Donner Model 1017 with Model 1253 plug-in
Oscilloscope	Vertical sensitivity: 1.0 mV/cm Bandwidth: 10 MHz Sweep time: 1 μ sec/cm Vertical channels: Two	Tektronics Model 533 with 1A1 plug-in
Spectrum Analyzer	Freq. range: 10 MHz - 2 GHz Dynamic range: 30 dB Dispersion (scan width): 20 - 200 kHz/cm I.F. bandwidth: 10 kHz	Singer Model SPA-3000
Digital Voltmeter	Accuracy: $\pm 1\%$ Resolution: 5 digits	Ballantine Model 3570 with Model 3572 plug-in
RF Detector	Freq. range: 10 MHz - 2 GHz Flatness: 0.5 dB Sensitivity: 1 mV/ μ W	Alfred Model 1001 with Model 1403 Low Frequency Compensation Network
Comb Generator	100, 25 and 5 MHz Markers	Alfred Model 7300
Pads, as required	10 - 20 dB	
For externally leveled units:		
Directional Coupler	Coupling factor: 10 or 20 dB	
RF Detector	Same as RF Detector above	

SECTION 5 - MAINTENANCE

5.1 INTRODUCTION.

5.1.1 GENERAL. The information provided in Section 5 contains performance verification procedures in accordance with published specifications, calibration adjustment procedures for periodic calibration, and troubleshooting procedures to isolate malfunctioning assemblies. All testing must be performed with the Model 650-10 installed in a properly calibrated Model 650 main frame.

5.1.2 INITIAL CONTROL SETTINGS. Unless otherwise specified, set the front-panel controls of the Model 650 and Model 650-10 for the performance tests, calibration adjustment, and troubleshooting procedures as follows:

Model 650

F_1 Bottom of band (0%)
 F_2 Top of band (100%)
 F_0 As desired
 M_1 As desired
 M_2 As desired
 FREQUENCY SWEEP/ $F_1 \rightarrow F_2$
 RETRACE OFF
 ΔF AMPLITUDE OFF
 MARKER AMPLITUDE OFF
 MODULATION AM OFF
 SWEEP TIME 01 sec (cal)
 SWEEP TRIGGER FREE RUN

Model 650-10

RF OUTPUT LEVELED
 FREQUENCY 01-1 GHz
 FILTER SWEEP
 RF SAMPLER INT.

5.1.3 REQUIRED TEST EQUIPMENT.

The test equipment required for performance testing, calibration adjustment and troubleshooting is given in Table 5-1. Test equipment other than those specified can be used provided their performance equals or exceeds the critical specifications given.

5.1.4 PERFORMANCE TESTS.

The performance tests given in para. 5.2 are provided to verify instrument operation in accordance with published specifications either as an incoming inspection or for periodic calibration tests. Access to the instrument interior is not required. The tests must be performed with the Model 650-10 installed in a correctly calibrated Model 650 main frame. If the Model 650-10 fails to meet any of the tested specifications, either return the instrument to the factory or recalibrate the instrument according to the procedure provided in para. 5.3. If the Model 650-10 malfunctions, refer to the troubleshooting procedure given in Figure 5-5.

5.1.5 CALIBRATION, ADJUSTMENT PROCEDURES.

The calibration adjustments given in para. 5-3 are provided to permit instrument adjustment either for periodic calibration or recalibration after replacing defective components. If the Model 650-10 cannot be adjusted to operate within specifications, either return the instrument to the factory or isolate and repair the defective assembly using the troubleshooting procedures given in Figure 5-5.

5.1.6 TROUBLE-SHOOTING PROCEDURES.

5.1.7 USE OF TROUBLE-SHOOTING FLOW DIAGRAM.

The flow diagram in Figure 5-5 is designed to quickly isolate the defective circuit or assembly when a malfunction occurs. Correct operating procedures, as explained in Section III of the Model 650 and Model 650-10 manuals, should be observed.

5.2 PERFORMANCE TESTS.

5.2.1 FREQUENCY ACCURACY:

Specification: 0.01 to 1 GHz band; ± 20 to ± 40 MHz, proportional to frequency. 1.0 to 2.0 GHz band; $\pm 2\%$.

Procedure:

- Connect frequency counter to 650-10 RF OUTPUT. Include required attenuation of RF signal to satisfy counter maximum input power limit and input sensitivity requirement.
- Set the Model 650/650-10 controls as follows:

Model 650

FREQUENCY Single/ F_0
 F_0 10 MHz

Model 650-10

FREQUENCY 0.01 - 1 GHz
 FILTER CW

- The counter should indicate 10 ± 20 MHz.
- Set F_0 to 100 MHz and observe counter readout.
- The counter should indicate 100 ± 22 MHz.
- Increase F_0 frequency in 100 MHz increments and observe counter readout for each setting.
- Counter should indicate frequency of dial setting ± 20 to ± 40 MHz, proportional to frequency.
- Set 650-10 FREQUENCY to 1 - 2 GHz band and measure frequency every 100 MHz.
- Counter should indicate frequency of dial setting $\pm 2\%$ (1 GHz ± 20 MHz to 2 GHz ± 40 MHz).

5.2.2 MAXIMUM LEVELED POWER and POWER LEVEL CONTROL RANGE.

Specifications:

Maximum Leveled Power: 0.01 to 1 GHz; greater than 2 mW (650-10CK), 2.5 mW (650-10C). 1 to 2 GHz; greater than 50 mW (both models).

Leveled Power Output Variation: $\pm .7$ dB, both bands.

Power Level Control Range: Leveled; greater than 10 dB, both bands. Unleveled; greater than 15 dB, both bands.

Procedure:

- a. Connect Model 8000/7051 and sensor or power meter and thermistor mount to 650-10 RF OUTPUT for power measurement. Include required attenuation to prevent sensor or thermistor mount damage.

- b. Set the Model 650/650-10 controls as follows:

Model 650

FREQUENCY SWEEP/ $F_1 \rightarrow F_2$

F_1 10 MHz

F_2 1 GHz

SWEEP TIME 1 sec.

RETRACE $\begin{cases} \text{ON (with power meter set-up)} \\ \text{OFF (with Model 8000/7051 set-up)} \end{cases}$

Model 650-10

FREQUENCY 01 - 1 GHz

RF OUTPUT LEVELED

FILTER SWEEP

- c. Adjust POWER LEVEL control to obtain maximum leveled power as indicated by UNLEVELED WHEN LIT light (the highest level which keeps the light off for the full-band sweep) and adjust power meter for on-scale reading.
- d. Rotate POWER LEVEL control counterclockwise and observe power meter reading to verify that rf output can be adjusted at least 10 dB below maximum leveled power.
- e. Readjust POWER LEVEL control to maintain maximum leveled power and set SWEEP TIME to 10 sec. (for power METER) or 0.1 sec (for 8000/7051). Observe power meter or 8000/7051 reading.
- f. Maximum leveled power should be greater than 2 mW (for 650-10CK) or 2.5 mW (for 650-10C) across the band. Power output variation should not exceed 1.4 dB.
- g. Set Model 650-10 FREQUENCY band switch to 1 - 2 GHz and set Model 650 SWEEP TIME for 1 sec.
- h. Readjust POWER LEVEL control for maximum leveled power as indicated by UNLEVELED WHEN LIT light and up-range the power meter or 8000/7051 to obtain an on-scale (screen) reading.
- i. Rotate the POWER LEVEL control counterclockwise and observe power reading to verify that rf output can be adjusted at least 10 dB below maximum leveled power.
- j. Readjust POWER LEVEL control to obtain maximum leveled power and set SWEEP TIME to 10 sec. (if using power meter).
- k. Maximum leveled power should be greater than 50 mW across the band. Power output variation should not exceed 1.4 dB.
- l. Set the Model 650 FREQUENCY mode selector to SINGLE and the SINGLE frequency selector to F_2 . Set the MANUAL SWEEP to F_2 . Set the Model 650-10 RF OUTPUT switch to UNLEVELED.

- m. Slowly rotate the F_2 control across the full band and observe the power reading. Note the frequencies of minimum and maximum power.
- n. Set the F_2 control at the minimum power frequency and rotate the POWER LEVEL control to verify that rf power can be varied at least 15 dB.
- o. Repeat step n at the maximum power frequency.
- p. Repeat steps m, n and o with the Model 650-10 FREQUENCY band switch set at .01 - 1 GHz.

5.2.3 SPURIOUS SIGNALS and RESIDUAL FM.

Specifications:

Spurious Signals: Harmonics: Greater than 20 dB below fundamental. Non-harmonics: Greater than 30 dB below fundamental.

Residual FM: Less than 20 kHz peak, .01 - 1 GHz; less than 15 kHz peak, 1 - 2 GHz.

Procedure:

- a. Connect spectrum analyzer to 650-10 RF OUTPUT. Include required attenuation to prevent damage to spectrum analyzer input.
- b. Set Model 650/650-10 controls as follows:
Model 650
FREQUENCY SINGLE
SINGLE F_1
 F_1 100KHz
Model 650-10
FREQUENCY 01 - 1 GHz
FILTER CW
- c. Tune spectrum analyzer to obtain center-screen display of 650-10 rf signal.
- d. Set spectrum analyzer for 200 kHz/cm dispersion (scan width) and observe spectral display.
- e. Harmonic spurious signals should be at least 20 dB below the fundamental; non-harmonic spurious signals should be at least 30 dB below fundamental.
- f. Set spectrum analyzer for 200 kHz/cm scan width and IF bandwidth for 10 kHz. Observe spectral display.
- g. Residual FM should not exceed 1 cm (1 cm = 20 kHz).
- h. Set Model 650-10 for 1 - 2 GHz operation and repeat step f.
- i. Residual FM should not exceed 7.5 mm (7.5 mm = 15kHz).

5.2.4 INTERNAL SQUARE-WAVE MODULATION.

Specification: 1 kHz internal square-wave modulation; symmetry better than 5%; rise time, 2.5 μ sec max; fall time, 2.5 μ sec max, unleveled. Symmetry better than 10%, rise time 30 μ sec, leveled.

Procedure:

- a. Connect rf detector to 650-10 RF OUTPUT with required attenuation to ensure square-law operation. Connect detector output to oscilloscope vertical input.

- b. Set Model 650/650-10 controls as follows:

Model 650

FREQUENCY SINGLE

SINGLE F_o

F_o As desired

MODULATION SQ. WAVE

Model 650-10

FREQUENCY As desired

FILTER CW MODULATED

- c. Adjust oscilloscope controls to obtain display of square wave modulated, detected rf signal. Observe the display.
- d. The square-wave symmetry should be better than 5% (unleveled), 10% (leveled).
- e. Set oscilloscope sweep time for 25 μ sec/cm and observe square-wave rise and fall time.
- f. Square wave rise time should be less than 1 mm (unleveled) or 1.2 cm (leveled). Fall time should also be less than 1 mm (both modes).

5.3 CALIBRATION ADJUSTMENTS.

5.3.1 POWER SUPPLY VOLTAGE CALIBRATION.

A separate adjustment control is provided for the -20V, +20V and -12V power supplies. The -35V supply is referenced to the -20V supply and not independently calibrated. The adjustment procedure is as follows:

- a. Connect the digital voltmeter return lead to ground, TP6.
- b. Connect digital voltmeter to TP2. Voltage should be $-20.00 \pm 0.5V$ dc. Adjust A2R43 for proper voltage reading, if required.
- c. Connect digital voltmeter to TP1. Voltage should be $+20.00 \pm .05V$ dc. Adjust A2R21 for proper voltage reading, if required.
- d. Connect digital voltmeter to TP3. Voltage should be $-12.0 \pm .1V$ dc. Adjust A3R35 for proper voltage reading, if required.
- e. Connect digital voltmeter to TP5. Set Model 650 FREQUENCY mode to single, the MODULATION selector to AM OFF, and check for $-35.5 \pm 1V$ dc.

5.3.2 TUNING RAMP VOLTAGE CALIBRATION. Adjustment of the tuning ramp voltages is independent of the tuning

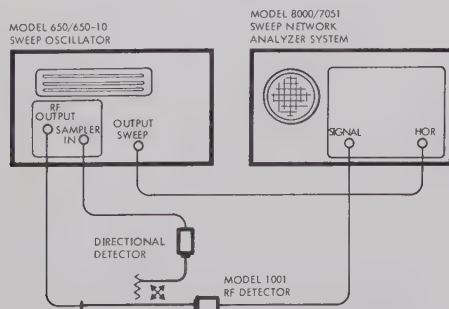
curve shaping adjustments. The up- and down-ramp amplitudes are individually adjusted within Function Generator Assembly A3, and the fixed offset applied to the summed ramps is adjusted in Linear Amplifier A4. The tuning ramp voltage calibration adjustment assures that proper-amplitude signals are provided to the shaping circuits in A4 for tuning the V.T.O. The adjustment procedure is as follows:

- a. Set the Model 650 FREQUENCY mode to SINGLE and the SINGLE selector to F_o . Set F_o to 10 MHz and connect the digital voltmeter to A3TP1, with the return lead to chassis ground, TP6.
- b. The voltage monitored should be $+5.00 \pm .02V$ dc. Adjust A3R10 for proper voltage reading, if required.
- c. Reset the F_o control to 1 GHz. The voltage monitored should be $-5.00 \pm .02V$ dc. Adjust A3R6 for proper voltage reading if required.
- d. Adjust F_o to the mid-scale position which produces a 0.00V dc reading at A3TP1.
- e. Connect the digital voltmeter to A3TP2. The voltage monitored should be 0.00V dc. Adjust A3R16, if necessary, to obtain 0.00V dc.
- f. Connect the digital voltmeter to chassis TP4 and set the F_o control to 10 MHz.
- g. The voltage monitored should be approximately 0.0V dc. Adjust A4R1, if necessary, to obtain approximately 0V dc.

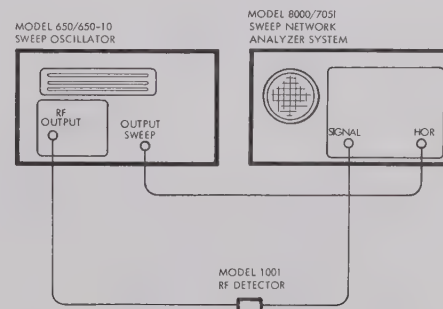
NOTE: Exact shape and upper limit of the VTO tuning ramp are not calibrated in this part of the procedure. Refer to the VTO Tuning Curve Diode Shaping Adjustment (para. 5.3.4.).

5.3.3 SAMPLER SENSITIVITY and RELATED LEVELER-AMPLIFIER ADJUSTMENTS. The internal sampler sensitivity adjustment sets the level of the sampler signal supplied to the Leveler-Amplifier Assembly, A5. The adjustment is set to obtain maximum leveled power with the POWER LEVEL control at mid-range, thus allowing the power to be set above full-band leveling, if desired, and also permitting power level control of at least 10 dB below maximum leveled power. The front-panel RF SAMPLER SENSITIVITY provides this same adjustment for Model 650-10's using an external sampler. The adjustment procedure for sampler sensitivity is as follows:

- a. Connect equipment as shown below:



FOR EXTERNALLY LEVELED UNITS



FOR INTERNALLY LEVELED UNITS

LEVELER-AMPLIFIER ADJUSTMENT TEST SET-UP

- b. Set the Model 650/650-10 controls as follows:

Model 650

FREQUENCY. SWEEP/F₁ → F₂

F₁ 10 MHz

F₂ 1 GHz

RETRACE OFF

Model 650-10

FREQUENCY 01 - 1 GHz

RF OUTPUT LEVELED

FILTER SWEEP

- c. Set POWER LEVEL control to mid-range and observe the display. Adjust Internal Sample Sensitivity control A5R17 for maximum leveled power.
- d. Adjust 8000/7051 vertical sensitivity to obtain full 10 cm vertical deflection.
- e. Rotate the POWER LEVEL control fully counterclockwise and observe the display.
- f. The detected, leveled rf output display should be reduced to less than 1 cm vertical deflection, indicating the output power can be reduced to 10 dB below maximum leveled power.
- g. If a 10 dB leveled power control range is not available, adjust the Minimum Power Limit adjustment A5R5 until a 10 dB control range is obtained.

If adjustment of A5R5 does not provide the required 10 dB range, rotate the Control Voltage Limit adjustment A5R42 fully clockwise to allow adjustment of A5R5 to obtain the 10 dB control range. Then readjust the Control Voltage Limit adjustment A5R42 as follows:

- h. Slowly rotate the POWER LEVEL control from full counterclockwise briefly toward full cw and back to full counterclockwise and observe oscilloscope display.
- i. Adjust the Control Voltage Limit adjustment A5R42 as required so that the oscilloscope display tracks the rotation of the POWER LEVEL control.
- j. While rotating the POWER LEVEL control and observing the tracking of the oscilloscope display, slowly adjust A5R42 counterclockwise until the display just ceases to

track the control rotation. Then readjust A5R42 approximately 3° clockwise.

- k. Set the Model 650 MODULATION selector to SQ. WAVE, the Model 650-10 FILTER switch to CW MODULATED and observe the oscilloscope display.

- l. If required, readjust A5R42 ± 3° to obtain optimum compromise between pulse rise time and overshoot.

- m. Repeat steps c through l until no further adjustment is required.

5.3.4 VTO TUNING CURVE DIODE SHAPING ADJUSTMENT.

NOTE

THE VTO TUNING CURVE DIODE SHAPING ADJUSTMENT IS NOT RECOMMENDED FOR FIELD CALIBRATION EXCEPT WHEN A MALFUNCTIONING VTO IS REPLACED.

The circuit is designed for extreme stability, and calibration of the tuning ramp voltage, as provided in the tuning ramp voltage adjustment, should be sufficient to maintain frequency accuracy with the factory-installed VTO. If it becomes necessary to use the following procedure in the field, proceed cautiously and do not attempt "short cuts."

Rotate A4R1 through A4R22 fully clockwise and connect equipment as shown below. Set the Model 650/650-10 controls as follows and adjust the Model 8000/7051 for a dual-trace display.

Model 650

FREQUENCY. SWEEP/F₁ → F₂

F₁ 1.0 GHz

F₂ 2.0 GHz

F₀ 1.5 GHz

RETRACE. OFF

SWEEP SPEED 0.1 sec

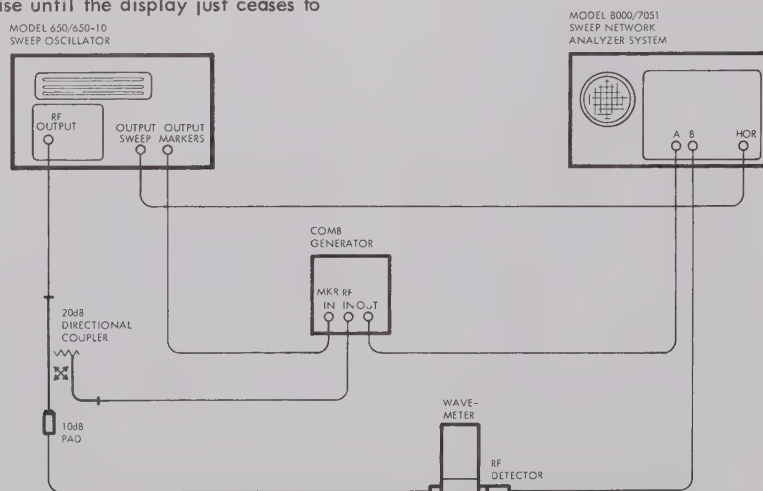
Model 650-10

FREQUENCY 1 - 2 GHz

RF OUTPUT LEVELED

POWER LEVEL. Maximum leveled power

FILTER SWEEP



VTO SHAPING ADJUSTMENT TEST SET-UP

As explained in Section IV, the diode shaping network shapes the non-linear tuning curve of the VTO to produce an overall linear tuning characteristic. Of the 10 diode sections, 5 shape the upper one-half of the tuning curve, 5 shape the lower half. The potentiometers associated with each diode permit section-by-section adjustment of the amount of shaping required. Additionally, two potentiometers (A4R1 & A4R2) are included to initially adjust the overall tuning curve before sectional shaping is performed. Figures 5-1 and 5-2 show an example of a VTO tuning curve before shaping, how the overall curve is affected by adjusting A4R1 and A4R2 and how the changes of the curve affect the marker presentations on the oscilloscope. Notice that areas of non-linearity in the curve are indicated on the display by unequal spacing of the comb markers. Ideal linearity is represented by exact spacing of the comb generator markers.

With F_0 set at 1.5 GHz, rotate the frequency meter dial about 1.5 GHz and observe the marker display to identify the 1.5 GHz comb marker. Then adjust A4R1 to align the 1.5 GHz comb marker with the 1.5 GHz F_0 marker as shown in Figure 5-1. Use the frequency meter to identify the 1.4 GHz comb marker and adjust A4R2 to align the comb marker with the F_0 marker set at 1.4 GHz.

Additional shaping of the tuning curve is performed on a section-by-section basis using the potentiometers associated with each of the ten diode sections. Each two potentiometers in a shaping section affect a section of the curve similar to the effect that A4R1 and A4R2 have on the overall curve; that is, the even-numbered potentiometers adjust the dc value of a section and the odd-numbered potentiometers adjust the slope. Additionally, the fixed resistor in series with the odd-numbered potentiometers affects the maximum amount of slope change available. Either half of the tuning curve may be adjusted first, but the shaping sequence must begin nearest the middle of the curve and finish at the end of the curve.

To determine which shaping section requires adjustment for a particular non-linearity, sequentially adjust each of the five

appropriate even-numbered potentiometers from full clockwise to full counterclockwise and back to full clockwise while observing the marker display. The even-numbered potentiometer that adjusts the comb marker to near alignment with the equivalent F_0 marker identifies the appropriate shaping section as shown in Figure 5-3. Once the section is identified, adjust the even-numbered potentiometer to position the appropriate comb marker at a point beyond the desired position (i.e. if shaping the lower half first, over-adjust the 1.3 GHz comb marker). Then use the odd-numbered potentiometer to adjust for the exact position as desired. Shaping the remaining portions of the tuning curve is accomplished in a similar manner. One other consideration should be made however.

Various non-linearities may require "negative" or "positive" shaping. That is, some non-linearities may require shunting some of the tuning voltage (as in the preceding examples), while others may need additional voltage to obtain the desired linearity. Incorrect shaping "polarity" is indicated by increased non-linearity as the shaping potentiometer is adjusted (i.e. the comb marker to be adjusted moves away from, rather than toward, the equivalent F_0 marker as shown in Figure 5-4).

Changing of the shaping polarity is also done on a section-by-section basis since such non-linearities are usually limited to small portions of the tuning curve. Once the appropriate section has been identified, by adjusting the even-numbered potentiometers and observing the marker display, shaping "polarity" is reversed by reversing the dc bias, ramp input polarity and diode polarity of the shaping section. After reversing the polarity and adjusting the section, re-adjustment of the previously shaped sections will be necessary since some interaction between sections does exist. After the full tuning curve has been shaped, a complete, sequential readjustment of the odd-numbered potentiometers should be made to further eliminate the effects of interaction and assure optimum linearity.

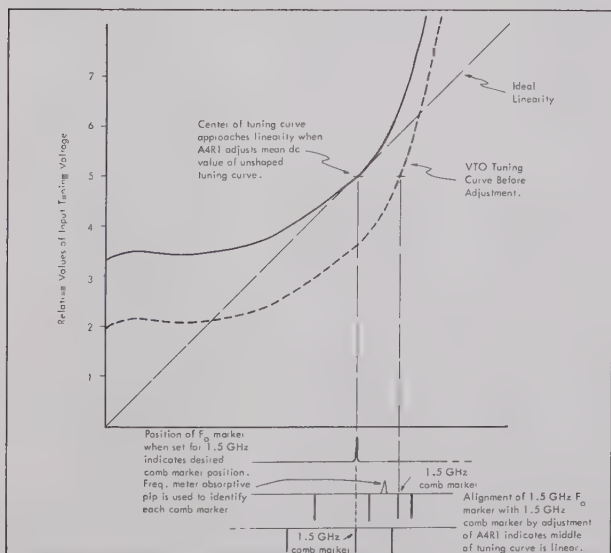


FIGURE 5-1. EXAMPLE OF VTO TUNING CURVE AND EFFECT OF A4R1 ADJUSTMENT

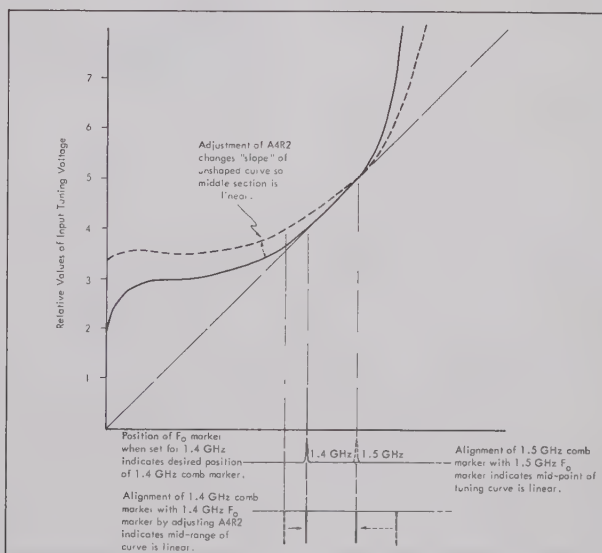


FIGURE 5-2. VTO TUNING CURVE AND EFFECT OF A4R2 ADJUSTMENT

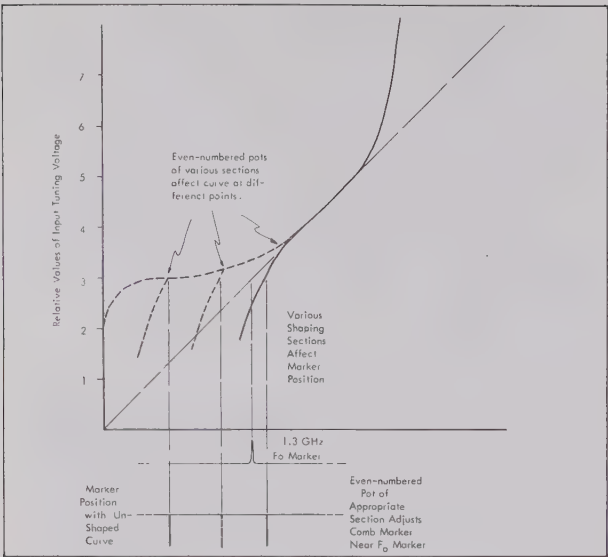


FIGURE 5-3. VTO TUNING CURVE AND EFFECT OF VARIOUS SHAPING SECTIONS

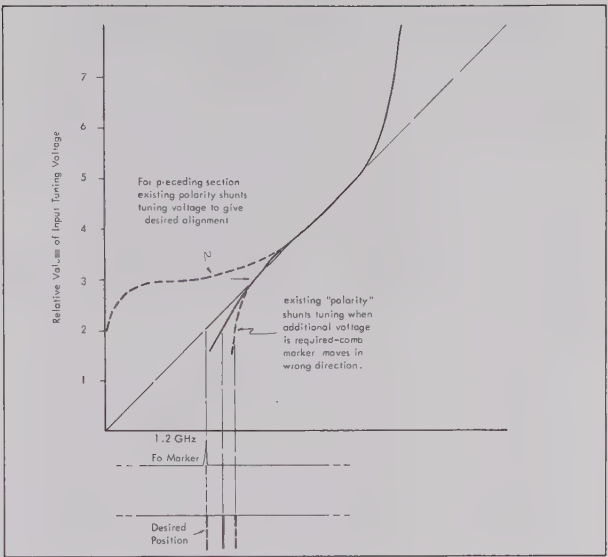


FIGURE 5-4. VTO TUNING CURVE AND EFFECT OF SHAPING "POLARITY"

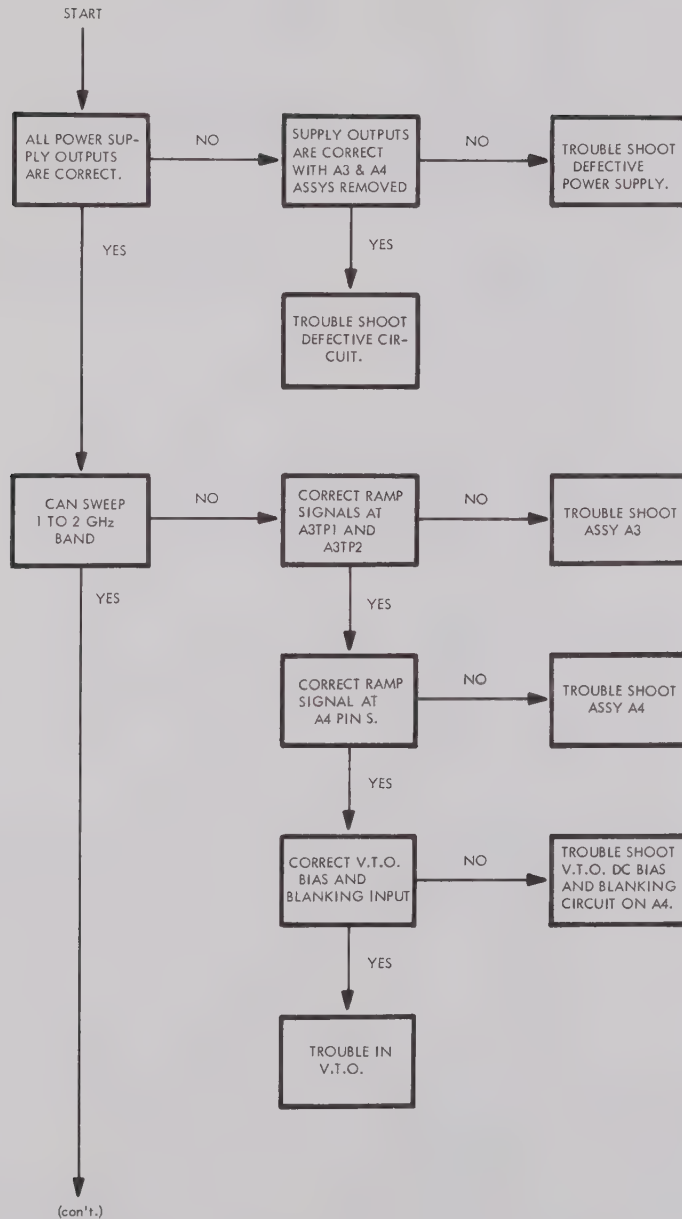


FIGURE 5-5. TROUBLESHOOTING FLOW DIAGRAM (Part 1 of 2)

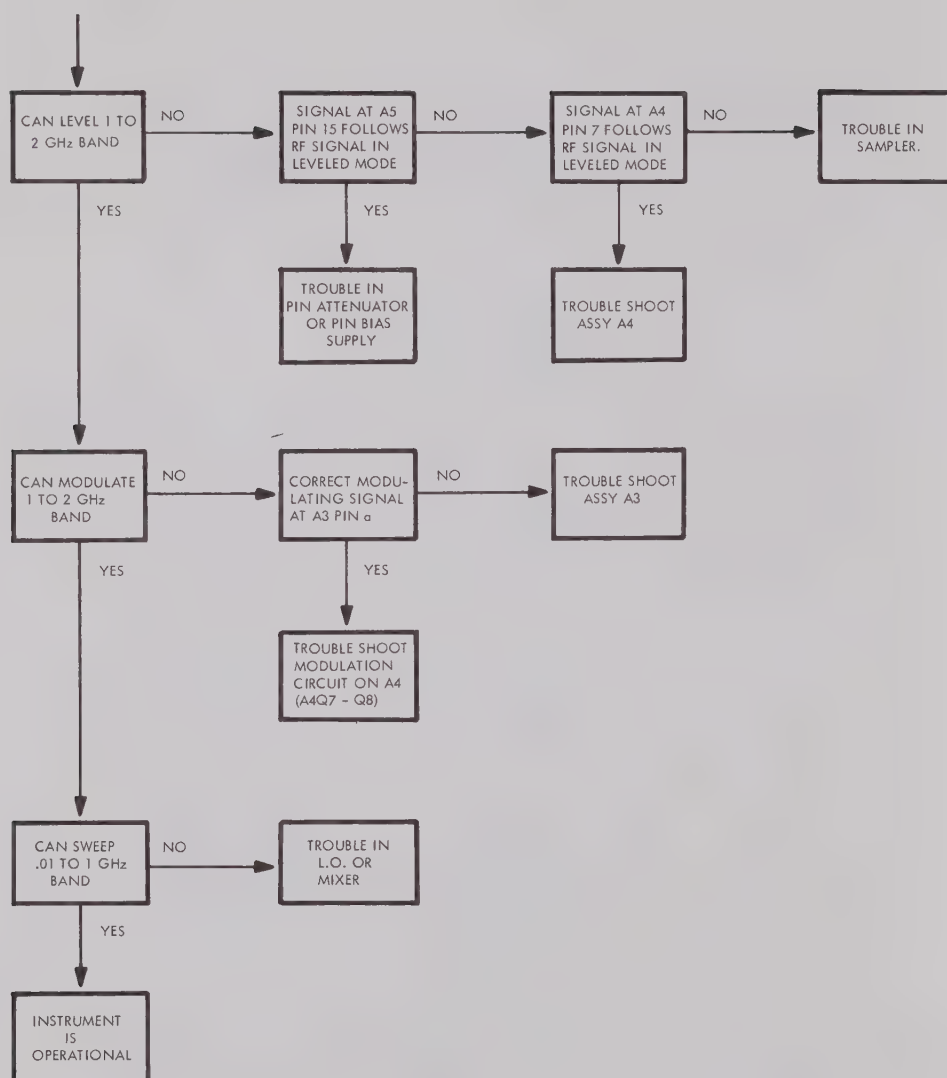


FIGURE 5-5. TROUBLESHOOTING FLOW DIAGRAM (Part 2 of 2)

FEDERAL SUPPLY CODE FOR TRUE MANUFACTURERS

FMC NO.	Full Name and Address of Vendor	FMC NO.	Full Name and Address of Vendor
00656	Aerovox Corporation, 740 Belleville Ave., New Bedford, Mass.	70309	Allied Control Co., Inc., 2 East End Ave., New York, New York
00686	Film Capacitors, Inc., 100 East 8th Street, Pabst, N.J.	70563	Amperite Co., Inc., 600 Palisade Ave., New Jersey
00816	Hughes Aircraft Co., Vacuum Div., 500 Superior Ave., Newport Beach, Calif.	70903	Belden Mfg. Co., Box 5070-A, Chicago, Ill. 60644
00853	Sangamo Electric Co., P.O. Box 128, Piquette, S.C.	71436	Chicago Condenser Corporation, 3253 Armitage Ave., Chicago, Ill. 60647
00866	Goe Engineering Co., 219-21 S. Mednik Ave., Los Angeles, Calif.	71450	CTS Corp., 1172 W. Beardsley, Elkhart, Ind.
01121	Allen Bradley Co., 136 W. Greenfield Ave., Milwaukee, Wisc.	71590	Centralab, Electronics Div., Globe Union, 934 Keefe Ave., Milwaukee, Wisconsin
01281	Pacific Semiconductor Co., 10451 W. Jefferson Blvd., Culver City, Calif.	71785	Cinch Mfg. Co., 1026 S. Homan Ave., Chicago 24, Ill.
01456	Microwave Development Laboratories, 87 Crescent Road, Needham Heights, Mass.	71895	Delavan Mfg. Co., Electro-Sonics Div., West Des Moines, Iowa
01963	Cherry Electrical Products Corp., Box 439, Highland Park, Ill.	72982	Erie Technological Products, Inc., 644 W. 12th St., Erie, Penn.
02111	Spectral Electric Corporation, 17070 E. Gale Ave., City of Industry, Calif. 91745	72012	M. Ducommun Mfg. Co., 580 Fifth Ave., New York, New York 90036
03508	G.E. Semiconductor, Electronics Park, Syracuse, N.Y., 13201	72136	Electro Motive Mfg. Co., Inc., S. Park & John Streets, Williamamantic, Conn.
03565	Dayton Electronic Products Co., 117 E. Helena St., Dayton, Ohio	72765	Drake Mfg. Co., 4626 N. Olcott Avenue, Harwood Heights, N.Y. 60656
03782	Alfred Electronics, 3176 Porter Drive, Palo Alto, California 94304	72983	Stancor Electronics (Essex Wire Corp.) 3501 W. Addison St., Chicago, Ill.
04009	Arrow-Hart, & Hegeman Elec. Co., 113 Hawthorne St., Hartford, Conn.	73293	Hughes Aircraft Co., Elec. Comp., Div., 500 Superior Ave., Newport Beach, Calif.
04713	Motorola Semiconductor Products, Inc., P.O. Box 955, Phoenix, Arizona	73445	Amperex Electronic Corporation, Box 418, 230 Duffy Ave., Hicksville, N.Y.
05783	Stewart Engineering Co., 467 Baan Creek Rd., Santa Cruz, Calif.	73899	JFD Elect. Co., Comp. Div., 15th Ave., at 62nd St., Brooklyn, N.Y.
05820	Wakefield Engineering Inc., 139-T Foundry St., Wakefield, Mass.	74542	Hoyt Electrical Inst. Works, Inc., 42 Carleton St., Cambridge, Mass.
06049	Topaz, 3802 Houston, San Diego, California 92110	74868	Amphenol Corp., Connector Div., 1830 S. 54th Ave., Chicago, Ill.
06555	Beede Electrical Instrument Co., Inc., Penacook, N.H.	74970	The E.F. Johnson Co., 1923 10th Ave., S.W. Waseca, Minn.
06980	Varian, 611 Hansen Way, Palo Alto, Calif. (BWO)	75376	Kurz Kasch, 1417 S. Broadway, Dayton, Ohio
07235	Radio Corp. of America, Electronic Components & Devices, 415 S. 5th St. Harrison, N.J.	75382	Kulka Electric Corp., 520 S. Fulton Ave., Mt. Vernon, N.Y.
07137	Transistor Electronics Corp., Box 6191, Minneapolis, Minn.	75042	IRC, Inc., 401 N. Broad St., Philadelphia, Penn.
07263	Fairchild Semiconductor, 545 Whisman Rd., Box 880, Mountain View, Calif.	75497	Lamson & Sessions, 5002 Tiedeman Rd., Cleveland, Ohio
08806	General Electric Corp., Min. Lamp Dept., Nela Park, Cleveland, Ohio	75915	Littlefuse, Inc., 800 E. Northwest Hwy., Des Plaines, Ill.
09022	Cornell-Dubilier, 50 Paris St., Newark, N.J. (Mica Caps)	76433	General Instrument Corp., 65 Gouverneur, Newark, N.J.
09023	Cornell-Dubilier, 50 Paris St., Newark, N.J. (Electrolytic Caps)	76487	James Millen Mfg. Co., Inc., 150 Exchange St., Malden, Mass.
09297	CP Electronics Inc., Columbus, Ind.	76854	Oak Mfg. Co., Crystal Lake, Ill.
		77342	Potter & Brumfield, Div., American Machine & Foundry Co., 1200 E. Broadway, Princeton, Ind.
		77557	Reliable Spring & Wire Forms Co., 3167 Fulton Rd., Cleveland, Ohio
		78553	Tinnerman Co., Dept. 16-T, P.O. Box 6688, Cleveland, Ohio
		78947	Ucinite Corporation, 459 Watertown St., Newtonville, Mass. 02160
		79493	J.W. Miller Co., 5915 S. Main St., Los Angeles, Calif. 90003
11312	Microwave Electronics Div. of Teledyne, 3165 Porter Drive, Palo Alto, Calif.	80294	Boums, Inc., 1200 Columbia Ave., Riverside, California 92507
12060	Diodes, Inc., 9261 Independence Ave., Chatsworth, Calif.	81073	Grayhill, Inc., 569 Hillgrove Ave., La Grange, Ill.
12122	Astrodyne, Inc., 2nd Ave., NW. Ind. Park, Burlington, Mass. 01803	81312	Winchester Electronics, Inc., Div. Litton Industries, 19 Willard Rd., Norwalk, Conn.
12360	Albany Products, 351 Connecticut Ave., South Norwalk, Conn.	82389	Switchcraft, Inc., 5555 N. Elston Ave., Chicago 30, Ill.
12697	Clarostat Mfg. Co., Washington St., Dover, N.H.	83186	Victory Engineering, 128 Springfield Ave., Springfield, New Jersey
13664	Workman Elec. Prod. Inc., Packing House Rd., Sarasota, Florida 33578	83701	Electronic Devices, Inc., 21 Grey Oaks Ave., Yonkers, N.Y.
13862	Alasco Rubber & Plastic Corp., 839 Malcom Rd., Burlingame, Calif.	88245	USECO, Div. of Litton Industries, 13536 Saticoy St., Van Nuys, Calif.
14026	Spatron, Inc., 715 S. Raymond Ave., Alhambra, California 91803	89536	John Fluke Mfg. Co., Inc., P.O. Box 7428, Seattle, Wash.
14433	International Telephone & Telegraph, 3301 Electronic Way, W. Palm Beach, Florida		
14482	Watkins-Johnson Co., 3333 Hillview, Palo Alto, California	91278	Stoesser Tool & Die, 3366 Fayette Dr., Mountain View, California
15582	Boy City Screw & Bolt Co., 601 Industrial Way, San Carlos, Calif.	91418	Radio Materials Co., 4242 W. Bryn Mawr Ave., Chicago 46, Ill.
15818	Amelco, 1300 Terra Bella, Mt. View, Calif. 94042	91637	Dale Electronics, Inc. (Subs. Lionel Corp.), Box 609, 1342 - 28th St., Columbus, Nebr.
16299	Corning Glass Works, Electronic Products Div., 3906 Electronics Dr., Raleigh, N.C.	91737	Gremar Mfg. Co., Wakefield, Mass.
16741	Triad Dist. Div. (Littion Ind.) 305 N. Briant St., Huntington, Ind.	91755	Harrison & Bonini, 1122 Harrison St., San Francisco, California
17474	Tranex, Inc., 1599 Stryerlin Rd., Mountain View, California	91827	K & F Tool Die & Mfg., Inc., 1203 Dell Ave., Campbell, California
17545	Atlantic Semiconductors, Inc., 905 Mattison Ave., Asbury Park, N.J. 07712	93332	Sylvania Electric Products, Inc., Semiconductor Div., 100 Sylvan Rd., Woburn, Mass.
17920	Warnecke Electron Tubes, 175 W. Oakton St., Des Plaines, Ill.	93389	Proto Stamping, Washington & Santa Fe, Los Angeles 54, Calif.
18489	Reliable Capacitors Co., 14716 Armita St., Van Nuys, Calif.	94144	Raytheon, 465 Centre St., Quincy, Mass. 02164
18915	Bircher Corp., The Industrial Div., 745 S. Monterey Pass Rd., Monterey Park, Calif.	94375	Automatic Metal Products Corp., 323 Berry St., Brooklyn 11, N.Y.
19701	Electro Mfg. Co., 800 North 21, Independence, Kansas	95263	Leecraft Mfg. Co., Inc., 44-35 - 21st St., Dept. E., Long Island City, N.Y.
		95354	Methode Electronics, Inc., 7447 W. Wilson Ave., Chicago, Ill.
		95987	Wessker Co., Inc., 4444 W. Irving Park, Chicago, Ill.
20286	Daytron, Inc., 1269 Terra Bella, Mountain View, California	96214	Texas Instruments, Inc., Semiconductor-Components Div., Box 5012, Dallas, Texas
20649	Universal Metal Products, 5924 N. Western Ave., Chicago 45, Ill.	96791	Borg Electronics, Div., Amphenol-Borg Electronics Corp., 120 S. Main St., Janesville, Wisc.
21030	Beckman Instrument, Inc., Helipot Div., 2500 Harbor Blvd., Fullerton, California	97464	Industrial Retaining Ring Co., 57 Cordier St., Irvington, N.J.
21743	Consect Corp., 4164 Greenbush Ave., Sherman Oaks, Calif.	99120	Plastic Capacitors, Inc., 2620 N. Clybourn Ave., Chicago, Ill.
22229	Union Carbide, KEMET Elect. Div., Mountain View, California	99313	Varian, 611 Hansen Way, Palo Alto, California (BWO)
23880	Stonford Applied Engineering, 340 Marton Ave., Santa Clara, Calif.	99942	Hoffman Electronics Corp., Semiconductor Div., Box 471, El Monte, California
24220	Gowanda, 179 Broadway Rd., Gowanda, N.Y.		
24796	Parelco, Inc., 26181 Avenida Aevoport, San Juan Capistrano, California		
27014	National Semi-Conductor Corp., 2950 San Ysidro Way, Santa Clara, Calif.		
28480	Hewlett-Packard, Paeco Div., 3215 Porter Drive, Palo Alto, California		

SECTION 6

PARTS LIST

List of Assemblies for Model 650-10 Plug-in

Circuit Reference	Alfred Part No.	Description	Schematics
A1	951907	Plug-in Chassis PC Board Assembly	D907376
A2	951905	Power Supply PC Board Assembly	D907397
A3	951888	Regulator PC Board Assembly	D907373
A4	951906	Function Generator PC Board Assembly	C907368
A5	951088	Linear Power Amplifier PC Board Assembly	C907371
A5	951088	Leveler Amplifier PC Board Assembly	D907033
A25	950278	H.V. Feedback PC Board Assembly	D907389

650-10 Plug-in Chassis Assembly

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.	CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
C1	13-58	<u>CAPACITORS</u> Fixed, elect., 1000 μ f, 50V	56289	TVL 1338	S1	101-31	<u>SWITCHES</u> Toggle, 2 pole, 3 position (SWEEP)		
J4	133-63	<u>INDICATORS</u> PC Board, 22 pin	81312	H8 28 SO	S2	102-134	Rotary w/R1 (LEVELED-UNLEVELED)		
J5	133-63	PC Board, 22 pin	81312	KZ 22 S	S3	102-136	Slide, DPDT (INT/EXT-RF Sampler)		
J6	131-33	BNC, panel mount (EXT RF SAMPLE INPUT)	91836	KC-79-46	S4	101-30	Toggle, DPDT (FREQUENCY)		
J7	131-82	Adapter, "N"/"OSM", panel mount (RF OUTPUT)	24931	33PP107-I	T1	91-213	<u>TRANSFORMERS</u> 115V/46V (center tap), 40V	03782	91-213
J8	(131-33)	Same as J6 (AM EXT INPUT)	(91836)	(KC-79-46)	TP1 thru TP5 TP6	133-28 133-29	<u>TEST POINTS</u> Tip jack, red Tip jack, black	74970 74970	105-802 105-803
K1	951886-02	<u>RELAYS</u> Coaxial (A980067-02)	03782	951886-02	RF Components				
K2	951886-01	Coaxial (A980065-01)	03782	951886-01					
P1 thru P5		<u>CONNECTORS (Plugs)</u> Not used			CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
P6 and P7	133-71	16 pin	74868	26-159-16	AT1	951041-02	<u>ATTENUATORS</u> PIN Diode Attenuator	03782	951041-02
Q1	81-150	<u>TRANSISTORS</u> 2N5193	04713	2N5193	FL1	980066	<u>FILTERS</u> Low pass	03782	980066
Q2 (Q9)		2N4920	04713	2N4920	MQR1	952101	<u>MIXERS</u> MWR-7260-0 (B980063)	03782	952101
Q3 (Q28)		2N5190	04713	2N5190	SA7	952100	<u>SAMPLER</u> .01 - 2 GHz	03782	952100
Q4 (Q35)		MJE 3055	04713	MFE 3055	Y1	952102	<u>RF OSCILLATORS</u> L.O. (1 GHz)	03782	952102
R1	(102-134)	<u>RESISTORS</u> Variable, 1K (Part of S2)	71450	211ND-45NS	Y2	980065	VTO (1 - 2 GHz)	03782	980065
R2	51-1.5K	Fixed, carb. dep., 1/2 w, $\pm$ 1%	73445	E-009-AB/B-1.5K					
R3*	34-100 Ω	Factory selected, nom. value 100 Ω	01121	CB 1015					
R4	71-122	Variable, 2.5K	71450	70-LT-2.5K					
R5	51-18K	Fixed, carb. dep., 18K, 1/2 w, $\pm$ 1%	73445	E-009-AB/B-18K					
R6	51-330 Ω	Fixed, carb. dep., 330 Ω , 1/2 w, $\pm$ 1%	73445	E-009-AB/B-330 Ω					
R7	51-56K	Fixed, carb. dep., 56K, 1/2 w, $\pm$ 1%	73445	E-009-AB/B-56K					
R8	56-100 Ω	Fixed, met. film, 100 Ω , 1/2 w, $\pm$ 1%	19701	MF7C-1000-F					
R9 and R10	41-180K	Fixed, comp., 180K, 1/2 w, $\pm$ 10%	01121	EB 1841					

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.	CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
<u>CAPACITORS</u>					<u>RESISTORS</u>				
A1C1 and A1C2	13-79	Fixed, elect., 500 μ f, 50V	56289	39D507G050GL4	A2R1	44-1.5 Ω	Fixed, WW, 1.5 Ω , 1/2 w, $\pm$ 5%	75042	BWH 1.5 Ω
A1C3 thru A1C5	13-62	Fixed, elect., 100 μ f, 50V	56289	TVL 1310	A2R2	34-1K	Fixed, comp., 1K, 1/4 w, $\pm$ 5%	01121	CB 1025
A1C6 and A1C7	14-37	Fixed, mylar, 0.1 μ f, 80V, $\pm$ 10%	56289	192P1049R8	A2R3	34-220 Ω	Fixed, comp., 220 Ω , 1/4 w, $\pm$ 5%	01121	CB 2215
<u>DIODES</u>					A2R4	51-2.2K	Fixed, carb. dep., 2.2K, 1/2 w, $\pm$ 5%	73445	E-009-AB/B-2.2K
A1CR1 and A1CR2	81-219	Rectifier, bridge, MDA 920A-4	04713	MDA 920A-4	A2R5	34-1M	Fixed, comp., 1M, 1/4 w, $\pm$ 5%	01121	CB 1055
<u>RESISTORS</u>					A2R6	34-10K	Fixed, comp., 10K, 1/4 w, $\pm$ 5%	01121	CB 1035
A1R1 thru A1R3	41-200K	Fixed, comp., 220K, 1/2 w, $\pm$ 10%	01121	EB 2241	A2R7	34-1.8K	Fixed, comp., 1.8K, 1/4 w, $\pm$ 5%	01121	CB 1825
A1R4 and A1R5	42-10K	Fixed, comp., 10K, 1 w, $\pm$ 10%	01121	GB 1031	A2R8	34-3.9K	Fixed, comp., 3.9K, 1/4 w, $\pm$ 5%	01121	CB 3925
A1R6	61-34	Fixed, WW, 91 Ω , 5 w, $\pm$ 5%	44655	995-5A-91 Ω	A2R9	51-2.7K	Fixed, dep. carb., 2.7K, 1/2 w, $\pm$ 5%	73445	E-009-AB/B-2.7K
					A2R10	(34-220 Ω)	Same as A2R3	(01121)	(CB 2215)
					A2R11	59-100K	Fixed, met. film, 100K, 1/4 w, $\pm$ 1%	19701	MF5C-1003-F
					A2R12	59-9.31K	Fixed, met. film, 9.31K, 1/4 w, $\pm$ 1%	19701	MF5C-9311-F
					A2R13 and A2R14	34-47 Ω	Fixed, comp., 47 Ω , 1/4 w, $\pm$ 5%	01121	CB 4705
					A2R15	(59-9.31K)	Same as A2R12	(19701)	(MF5C-9311-F)
					A2R16	(59-100K)	Same as A2R11	(19701)	(MF5C-1003-F)
					A2R17	59-2.49K	Fixed, met. film, 2.49K, 1/4 w, $\pm$ 1%	19701	MF5C-2491-F
					A2R18	59-750 Ω	Fixed, met. film, 750 Ω , 1/4 w, $\pm$ 1%	19701	MF5C-7500-F
					A2R19	59-1.82K	Fixed, met. film, 1.82K, 1/4 w, $\pm$ 1%	19701	MF5C-1821-F
					A2R20	59-3.24K	Fixed, met. film, 3.24K, 1/4 w, $\pm$ 1%	19701	MF5C-3241-F
					A2R21	71-96	Variable, WW, 100 Ω , 1 w, $\pm$ 10%	21030	79PR100
					A2R22	59-953 Ω	Fixed, met. film, 953 Ω , 1/4 w, $\pm$ 1%	19701	MF5C-9530-F
					A2R23	(51-2.7K)	Same as A2R9	(73445)	(E-009-AB/B-2.7K)
					A2R24	(34-1.8K)	Same as A2R7	(01121)	(CB 1825)
					A2R25	(34-220 Ω)	Same as A2R3	(01121)	(CB 2215)
					A2R26	(51-2.2K)	Same as A2R4	(73445)	(E-009-AB/B-2.2K)
					A2R27	(34-1M)	Same as A2R5	(01121)	(CB 1055)
					A2R28	(34-220 Ω)	Same as A2R3	(01121)	(CB 2215)
					A2R29	(44-1.5 Ω)	Same as A2R1	(75042)	(BWH 1.5 Ω)
					A3R30	(34-1K)	Same as A2R2	(01121)	(CB 1025)
					A3R31	(34-10K)	Same as A2R6	(01121)	(CB 1035)
					A3R32	(59-100K)	Same as A2R32	(19701)	(MF5C-1003-F)
					A3R33	(59-9.31K)	Same as A2R12	(19701)	(MF5C-9311-F)
					A3R34	(59-866 Ω)	Fixed, met. film 866 Ω , 1/4 w, $\pm$ 1%	19701	MF5C-8660-F
					A3R35 and A3R36	(34-47 Ω)	Same as A2R13	(01121)	(CB 4705)
					A2R37	(59-9.31K)	Same as A2R12	(19701)	(MF5C-9311-F)
					A2R38	(59-100K)	Same as A2R11	(19701)	(MF5C-1003-F)
					A2R39	(59-2.49K)	Same as A2R17	(19701)	(MF5C-2491-F)
					A2R40	(59-750 Ω)	Same as A2R18	(19701)	(MF5C-7500-F)
					A2R41	(59-1.82K)	Same as A2R19	(19701)	(MF5C-1821-F)
					A2R42	(59-3.24K)	Same as A2R20	(19701)	(MF5C-3241-F)
					A2R43	(71-96)	Same as A2R21	(21030)	(79PR100)
					A2R44	(59-953 Ω)	Same as A2R22	(19701)	(MF5C-9530-F)
					A2R45	34-27K	Fixed, comp., 27K, 1/4 w, $\pm$ 5%	01121	CB 2735
					A2R46	34-3.3K	Fixed, comp., 3.3K, 1/4 w, $\pm$ 5%	01121	CB 3325
					A2R47	59-19.6K	Fixed, met. film, 19.6K, 1/4 w, $\pm$ 1%	19701	MF5C-1962-F
					A2R48 and A2R49	34-6.8K	Fixed, comp., 6.8K, 1/4 w, $\pm$ 5%	01121	CB 6825
					A2R50	34-1.2K	Fixed, comp., 1.2K, 1/4 w, $\pm$ 5%	01121	CB 1225
					A2R51	34-100 Ω	Fixed, comp., 100 Ω , 1/4 w, $\pm$ 5%	01121	CB 1015
					A2R52	(34-1K)	Same as A2R2	(01121)	(CB 1025)
					A2R53	(34-100 Ω)	Same as A2R51	(01121)	(CB 1015)
					A2R54	44-.82 Ω	Fixed, WW, .82 Ω , 1/2 w, $\pm$ 5%	75042	BWH .82 Ω
					A2R55	56-4.22K	Fixed, met. film, 4.22K, 1/2 w, $\pm$ 1%	19701	MF7C-4221-F
					A2R56	56-3.65K	Fixed, met. film, 3.65K, 1/2 w, $\pm$ 1%	19701	MF7C-3651-F
					A2R57	(34-3.9K)	Same as A2R8	(01121)	(CB 3925)
					A2R58	59-1K	Fixed, Met. film, 1K, 1/4 w, $\pm$ 1%	19701	MF5C-1001-F

A2 Regulator PC Board Assembly 951905

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.	CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
<u>CAPACITORS</u>					<u>DIODES</u>				
A2C1	12-58	Fixed, ceramic, .1 μ f, 16V	56289	HY 450	A2CR1	Not used			
A2C2		Fixed, ceramic, 2.2 μ f, 25V	56289	5C023225X/0250B3	A2CR2	1N4385	76433	1N4385	
A2C3 and A2C4	12-56	Fixed, ceramic, .01 μ f, 25V	56289	HY 520	A2CR3	1N752A (Zener)	04713	1N752A	
A2C5		Same as A2C2	(56289)	5C023225X/0250B3	A2CR4	1N459	07263	1N459	
A2C6	(12-58)	Same as A2C1	(56289)	(HY 450)	A2CR5	LVA 47A (Zener)	TRW	LVA 47A	
A2C7 thru A2C9	(12-56)	Same as A2C3	(56289)	(HY 520)	A2CR6	Same as A2CR3	(04713)	(1N752A)	
A2C10	14-30	Fixed, mylar, .1 μ f, 100V	37942	PVC 101	A2CR7	Same as A2CR2	(76433)	(1N4385)	
A2C11	14-37	Fixed, mylar, .1 μ f, 80V $\pm$ 10%	56289	192P1049R8	A2CR8	Not used			
<u>TRANSISTORS</u>					A2CR9	Same as A2CR4	(07263)	(1N459)	
A2Q1		Not used			A2CR10	Same as A2CR5	(TRW)	(LVA 47A)	
A2Q2		MPS A14	04713	MPS A14	A2CR11 thru A2CR14	1N4002	04713	1N4002	
A2Q3	81-172	2N4248	07263	2N4248					
A2Q4	81-115	2N3565	07263	2N3565					
A2Q5 and A2Q6	81-215	2N5134	07263	2N5134					
A2Q7	(81-172)	Same as A2Q3	(07263)	(2N4248)					
A2Q8	81-131	2N3563	07263	2N3563					
A2Q9	81-140	2N5087	04713	2N5087					
A2Q10	(81-115)	Same as A2Q4	(07263)	(2N3565)					
A2Q11	(81-131)	Same as A2Q8	(07263)	(2N3563)					
A2Q12	(81-140)	Same as A2Q9	(04713)	(2N5087)					
A2Q13	(81-115)	Same as A2Q4	(07263)	(2N3565)					
A2Q14	81-113	2N4956	07263	2N4956					
A2Q15	(81-115)	Same as A2Q4	(07263)	(2N3565)					
A2Q16	(81-172)	Same as A2Q3	(07263)	(2N4248)					
A2Q17	(81-115)	Same as A2Q4	(07263)	(2N3565)					
A2Q18	81-214	2N5143	07263	2N5143					
A2Q19		MPS A66							
A2Q20	(81-214)	Same as A2Q18	(07263)	(2N5143)					
A2Q21	81-189	2N4917	07263	2N4917					
A2Q22	(81-140)	Same as A2Q9	(04713)	(2N5087)					
A2Q23	(81-115)	Same as A2Q4	(07263)	(2N3565)					
A2Q24	(81-189)	Same as A2Q21	(07263)	(2N4917)					
A2Q25	(81-140)	Same as A2Q9	(04713)	(2N5087)					
A2Q26	(81-115)	Same as A2Q4	(07263)	(2N3565)					
A2Q27	(81-113)	Same as A2Q14	(07263)	(2N4956)					
A2Q28		Not used							
A2Q29	81-241	TD 400	56289	TD 400					
A2Q30 and A2Q31	81-181	2N4889	07263	2N4889					
A2Q32	81-266	2N5184	07326	2N5184					
A2Q33	(81-181)	Same as A2Q30	(07263)	(2N4889)					
A2Q34	(81-214)	Same as A2Q18	(07263)	(2N5143)					

A3 Function Generator PC Board Assy. 951888.

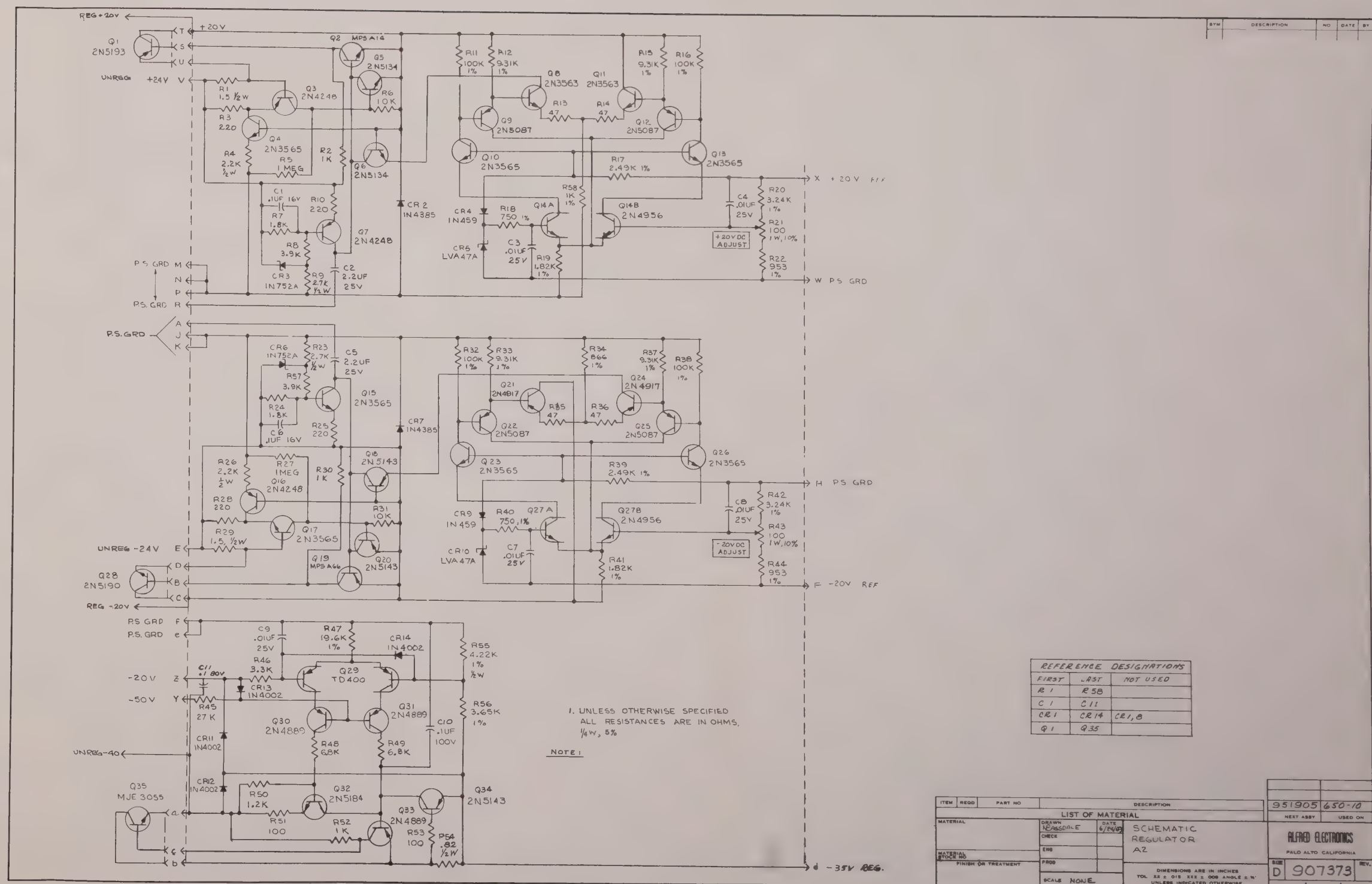
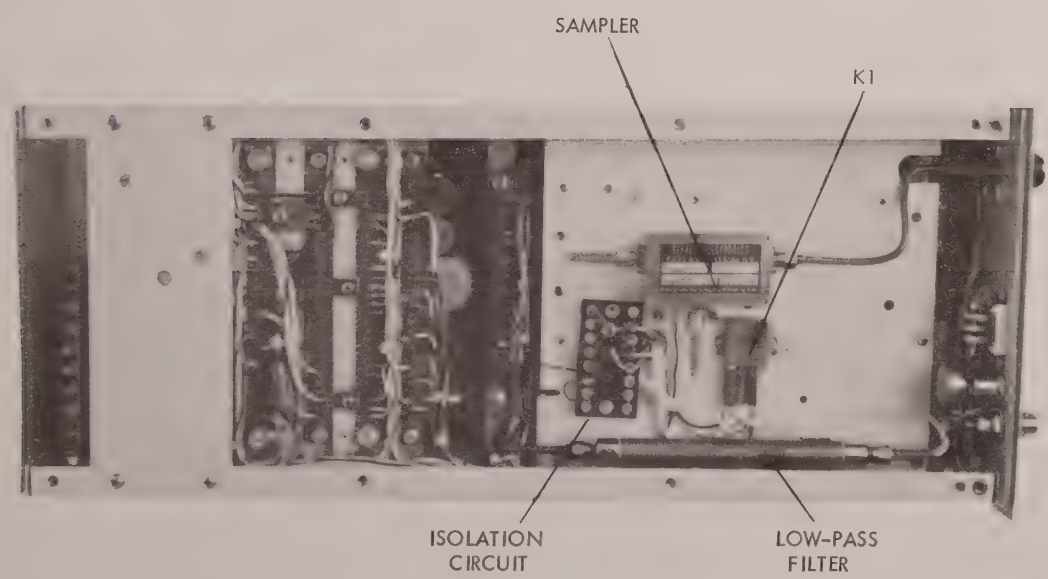
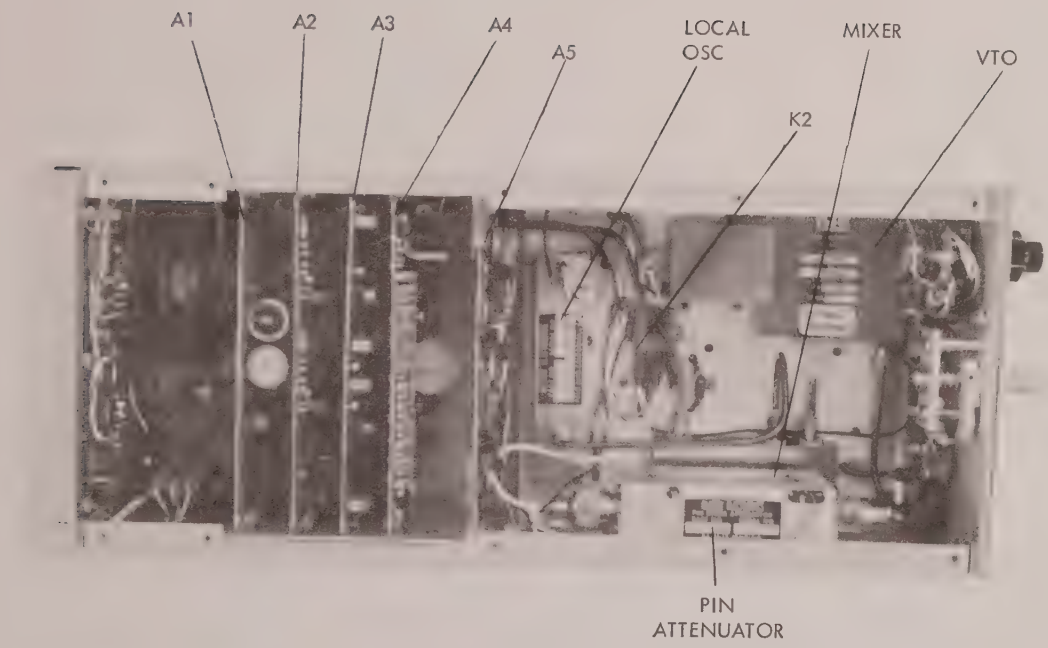
CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
<u>CAPACITORS</u>				
A3C1	13-70	Fixed, tant., 1 μ f, 35V	22229	K1C35K
A3C2	14-37	Fixed, mylar, .1 μ f, 80V	56289	192P1049R8
A3C3 and A3C4	12-27	Fixed, ceramic, 270 pf, 1KV	71590	DD 271
A3C5	13-49	Fixed, elect., 50 μ f, 25V	56289	TE 1209
A3C6	13-69	Fixed, tant., 4.7 μ f, 35V	22229	K4R7C35K
A3C7	(13-49)	Same as A3C5	(56289)	(TE 1209)
A3C8	14-40	Fixed, mylar, .015 μ f, 80V	56289	192P1539R8
A3C9	(13-69)	Same as A3C6	(22229)	(K4R7C35K)
<u>DIODES</u>				
A3CR1 thru A3CR3	81-41	1N459	07263	1N459
<u>TRANSISTORS</u>				
A3Q1 and A3Q2	81-115	2N3565	07263	2N3565
A3Q3	81-179	2N4931	04713	2N4931
A3Q4 thru A3Q6	81-129	2N3645	07263	2N3645
A3Q7 and A3Q8	81-140	2N5087	04713	2N5087
A3Q9		Not used		
A3Q10	(81-140)	Same as A3Q7	(04713)	(2N5087)
<u>RESISTORS</u>				
A3R1	56-51K	Fixed, met. film, 51K, 1/2 w, $\pm 1\%$	19701	MF7C-5102-F
A3R2	41-1.8K	Fixed, comp., 1.8K, 1/2 w, $\pm 10\%$	01121	EB 1821
A3R3	41-150K	Fixed, comp., 150K, 1/2 w, $\pm 10\%$	01121	EB 1541
A3R4	41-10K	Fixed, comp., 10K, 1/2 w, $\pm 10\%$	01121	EB 1031
A3R5	56-10K	Fixed, met. film, 10K, 1/2 w, $\pm 1\%$	19701	MF7C-1002-F
A3R6	71-94	Variable, 5K, 1 w, $\pm 10\%$	21030	79PR5K
A3R7 and A3R8		Not used		
A3R9	56-26.1K	Fixed, met. film, 26.1K, 1/2 w, $\pm 1\%$	19701	MF7C-2612-F
A3R10	(71-94)	Same as A3R6	(21030)	(79PR5K)
A3R11	56-23.7K	Fixed, met. film, 23.7K, 1/2 w, $\pm 1\%$	19701	MF7C-2372-F
A3R12	56-30.1K	Fixed, met. film, 30.1K, 1/2 w, $\pm 1\%$	19701	MF7C-3012-F
A3R13		Not used		
A3R14	56-19.6K	Fixed, met. film, 19.6K, 1/2 w, $\pm 1\%$	19701	MF7C-1962-F
A3R15	(56-26.1K)	Same as A3R9	(19701)	(MF7C-2612-F)
A3R16	71-93	Variable, 10K, 1w, $\pm 10\%$	21030	79PR10K
A3R17	(56-26.1K)	Same as A3R9	(19701)	(MF7C-2612-F)
A3R18	(56-19.6K)	Same as A3R14	(19701)	(MF7C-1962-F)
A3R19		Not used		
A3R20	(59-3.09K)	Fixed, met. film, 3.09K, 1/4 w, $\pm 1\%$	19701	MF5C-3091-F
A3R21	59-316 Ω	Fixed, met. film, 316 Ω , 1/4 w, $\pm 1\%$	19701	MF5C-3160-F
A3R22	34-100K	Fixed, comp., 100K, 1/4 w, $\pm 5\%$	01121	CB 1045
A3R23	34-6.8K	Fixed, comp., 6.8K 1/4 w, $\pm 5\%$	01121	CB 6825
A3R24	(34-100K)	Same as A3R22	(01121)	(CB 1045)
A3R25	(34-6.8K)	Same as A3R23	(01121)	(CB 6825)
A3R26 thru A3R29	34-5.6K	Fixed, comp., 5.6K, 1/4 w, $\pm 5\%$	01121	CB 5625
A3R30	34-2.2K	Fixed, comp., 2.2K, 1/4 w, $\pm 5\%$	01121	CB 2225
A3R31	43-10 Ω	Fixed, comp., 10 Ω , 2 w, $\pm 10\%$	01121	HB 1001
A3R32	(34-2.2K)	Same as A3R30	(01121)	(CB 2225)
A3R33	34-1.2K	Fixed, comp., 1.2K, 1/4 w, $\pm 5\%$	01121	CB 1225
A3R34	34-1.8K	Fixed, comp., 1.8K, 1/4 w, $\pm 5\%$	01121	CB 1825
A3R35	(71-94)	Same as A3R6	(21030)	(79PR5K)
A3R36	34-1K	Fixed, comp., 1K, 1/4 w, $\pm 5\%$	(01121)	(CB 1035)
<u>INTEGRATED CIRCUITS</u>				
A3U1 and A3U2	84-4	LM 201A (Operational Amplifier)	27014	LM 201A

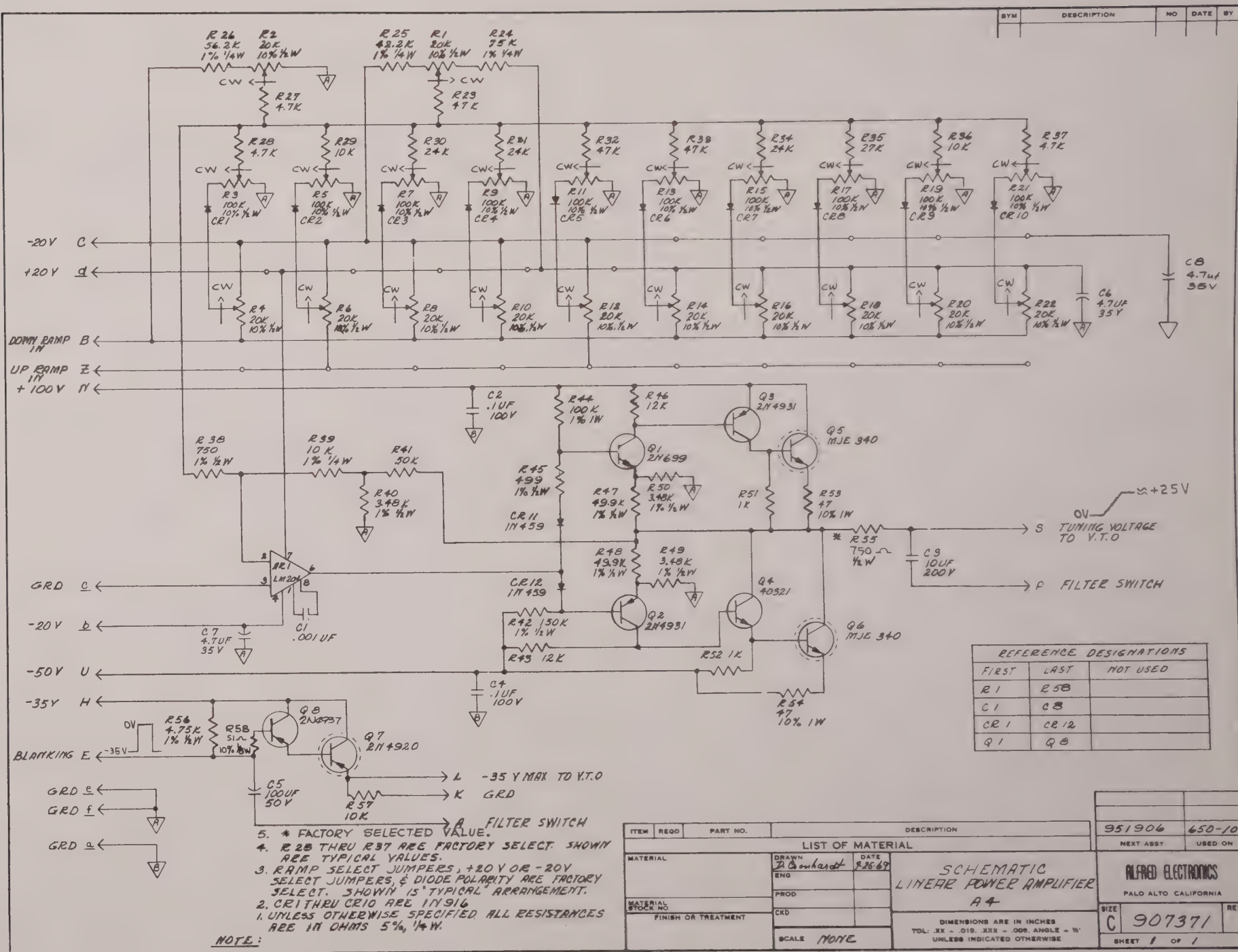
A4 Linear Power Amplifier PC Board Assy. 951906

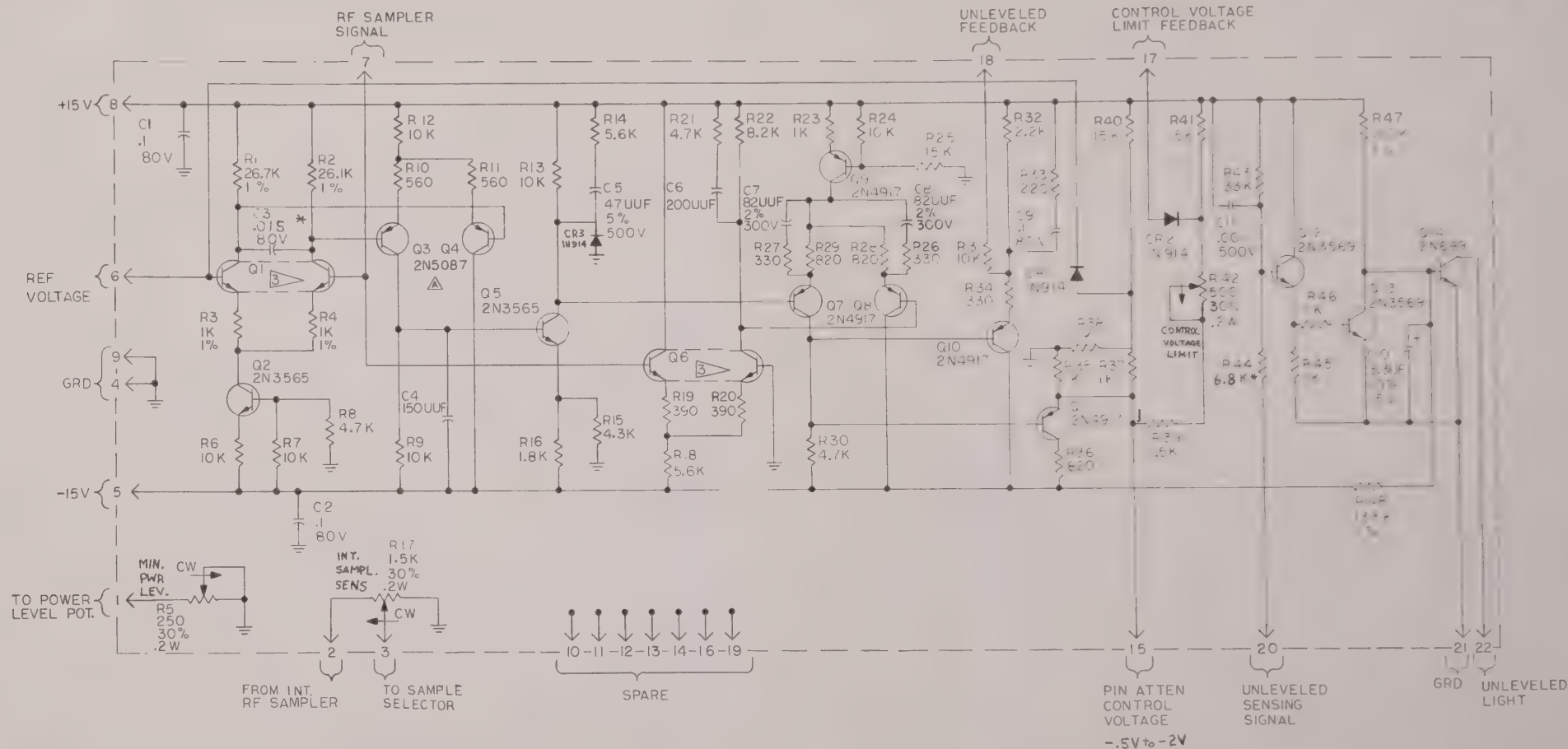
CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.	CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
<u>CAPACITORS</u>					<u>RESISTORS</u>				
A4C1	12-2	Fixed, ceramic, .001 μ f, 1KV, $\pm 10\%$	72982	851-X5R-102K	A4R1 and A4R2	71-146	Variable, 20K, 1/2 w, $\pm 10\%$	71450	190PC203A
A4C2	12-34	Fixed, ceramic, .1 μ f 100V	91418	BT010	A4R3	71-145	Variable, 100K, 1/2 w, $\pm 10\%$	71450	190PC104A
A4C3	14-23	Fixed, mylar, 10 μ f, 200V	18489	VMT 106 H2A	A4R4	(71-146)	Same as A4R1	(71450)	(190PC203A)
A4C4	(12-34)	Same as A4C2	(91418)	(BT 010)	A4R5	(71-145)	Same as A4R3	(71450)	(190PC104A)
A4C5	13-62	Fixed, elect., 100 μ f, 50V	56289	TVA 1310	A4R6	(71-146)	Same as A4R1	(71450)	(190PC203A)
A4C6 thru A4C8	13-69	Fixed, tant., 4.7 μ f, 35V	22229	K4R7C35K	A4R7	(71-145)	Same as A4R3	(71450)	(190PC104A)
<u>DIODES</u>					A4R8	(71-146)	Same as A4R1	(71450)	(190PC203A)
A4CR1 thru A4CR10	81-207	1N916	93332	1N5	A4R9	(71-145)	Same as A4R3	(71450)	(190PC104A)
A4CR11 and A4CR12	81-41	1N459	93332	1N459	A4R10	(71-146)	Same as A4R1	(71450)	(190PC203A)
<u>TRANSISTORS</u>					A4R11	(71-145)	Same as A4R3	(71450)	(190PC104A)
A4Q1	81-72	2N699	96214	2N699	A4R12	(71-146)	Same as A4R1	(71450)	(190PC203A)
A4Q2 and A4Q3	81-179	2N4931	04713	2N4931	A4R13	(71-145)	Same as A4R3	(71450)	(190PC104A)
A4Q4	81-127	40321	02735	40321	A4R14	(71-146)	Same as A4R1	(71450)	(190PC203A)
A4Q5 and A4Q6	81-180	MFE 340	04713	MFE 430	A4R15	(71-145)	Same as A4R3	(71450)	(190PC104A)
A4Q7	81-150	2N4920	04713	2N4920	A4R16	(71-146)	Same as A4R1	(71450)	(190PC203A)
A4Q8	(81-179)	Same as A4Q2	(04713)	(2N4931)	A4R17	(71-145)	Same as A4R3	(71450)	(190PC104A)
					A4R18	(71-146)	Same as A4R1	(71450)	(190PC203A)
					A4R19	(71-145)	Same as A4R3	(71450)	(190PC104A)
					A4R20	(71-146)	Same as A4R1	(71450)	(190PC203A)
					A4R21	(71-145)	Same as A4R3	(71450)	(190PC104A)
					A4R22	(71-146)	Same as A4R1	(71450)	(190PC203A)
					A4R23	34-47K	Fixed, comp., 47K, 1/4 w, $\pm 5\%$	01121	CB 4735
					A4R24	59-75K	Fixed, met. film, 75K, 1/4 w, $\pm 1\%$	19701	MF5C-7502-2
					A4R25	59-42.2K	Fixed, met. film, 42.2K, 1/4 w, $\pm 1\%$	19701	MF5C-4222-F
					A4R26	59-56.2K	Fixed, met. film, 56.2K, 1/4 w, $\pm 1\%$	19701	MF5C-5622-F
					A4R27 and A4R28	34-4.7K	Fixed, comp., 4.7K, 1/4 w, $\pm 5\%$	01121	CB 4725
					A4R29	34-10K	Fixed, comp., 10K, 1/4 w, $\pm 5\%$	01121	CB 1035
					A4R30 and A4R31	34-24K	Fixed, comp., 24K, 1/4 w, $\pm 5\%$	01121	CB 2435
					A4R32 and A4R33	(34-47K)	Same as A4R23	(01121)	(CB 4735)
					A4R34	(34-24K)	Same as A4R30	(01121)	(CB 2435)
					A4R35	34-27K	Fixed, comp., 27K, 1/4 w, $\pm 5\%$	01121	CB 2735
					A4R36	(34-10K)	Same as A4R29	(01121)	(CB 1035)
					A4R37	(34-4.7K)	Same as A4R27	(01121)	(CB 4725)
					A4R38	56-750 Ω	Fixed, met. film, 750 Ω , 1/2 w, $\pm 1\%$	19701	MF7C-7500-F
					A4R39	59-10K	Fixed, met. film, 10K, 1/4 w, $\pm 1\%$	19701	MF5C-1002-F
					A4R40	56-3.48K	Fixed, met. film, 3.48K, 1/2 w, $\pm 1\%$	19701	MF7C-3481-F
					A4R41	53-50K	Fixed, comp., 50K, 1 w, $\pm 1\%$	19701	MF7C-1503-F
					A4R42	56-150K	Fixed, met. film, 150K, 1/2 w, $\pm 1\%$	19701	MF7C-1503-F
					A4R43	34-12K	Fixed, comp., 12K, 1/4 w, $\pm 1\%$	01121	CB 1235
					A4R44	56-100K	Fixed, met. film, 100K, 1/2 w, $\pm 1\%$	19701	MF7C-1003-F
					A4R45	56-499 Ω	Fixed, met. film, 499 Ω , 1/2 w, $\pm 1\%$	19701	MF7C-4990-F
					A4R46	(34-12K)	Same as A4R43	(01121)	(CB 1235)
					A4R47 and A4R48	56-49.9K	Fixed, met. film, 49.9K, 1/2 w, $\pm 1\%$	19701	MF7C-4992-F
					A4R49 and A4R50	(56-3.48K)	Same as A4R40	(19701)	(MF7C-3481-F)
					A4R51 and A4R52	34-1K	Fixed, comp., 1K, 1/4 w, $\pm 5\%$	01121	CB 1025
					A4R53 and A4R54	42-47 Ω	Fixed, comp., 47 Ω , 1 w, $\pm 10\%$	01121	CB 4701
					A4R55*	(56-750 Ω)	Same as A4R38	(19701)	(MF7C-7500-F)
					A4R56	56-4.75K	Fixed, met. film, 4.75K, 1/2 w, $\pm 1\%$	19701	MF7C-4751-F
					A4R57	(34-10K)	Same as A4R29	(01121)	(CB 1035)
					A4R58	33-51	Fixed, comp., 51 Ω , 1/8 w, $\pm 10\%$	01121	TS 5101
					<u>INTEGRATED CIRCUITS</u>				
					A4U1	84-1	LM 201-6848 (Operational Amplifier)	27014	LM 201AH

(A5 Leveler Amplifier PC Board Assy. 951088)

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.	CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
CAPACITORS					RESISTORS (Contd)				
A5C1 and A5C2	14-37	Capacitor, fixed film, 0.1 μ f, 10%, 80V	56289	192P1049R8	A5R36 A5R37 and A5R38 A5R39	(34-820 Ω) (34-1K) 34-1.5K	Same as A5R28 Same as A5R23 Fixed, comp., 1.5K, 1/4 w, $\pm$ 5%	(01121) (01121) 01121	(CS 8215) (CS 1025) CS 1525
A5C4	11-36	Capacitor, fixed, dipped, mica, 47 pf, $\pm$ 5%	72136	DM-5-151-K	A5R40 and A5R41 A5R42	(34-15K) 71-134	Same as A5R25 Variable, comp., 500 Ω , 2 w, $\pm$ 30%	(01121) 71450	(CS 1535) U201R501B
A5C5	11-25	Fixed, dipped mica, 47 pf, $\pm$ 5%	00853	D15-47 pf	A5R43 A5R44*	34-33K 34-6.8K	Fixed, comp., 33K, 1/4 w, $\pm$ 5% Fixed, comp., 6.8K, 1/4 w, $\pm$ 5%	01121 01121	CS 3335 CS 6825
A5C6	11-37	Fixed, dipped mica, 200 pf, $\pm$ 10% 100V	72136	DM-10-201-K	A5R45 and A5R46 A5R47 A5R48	(34-1K) 59-100K 59-133K	Same as A5R23 Fixed, MF, 100K, 1/4 w, $\pm$ 1% Fixed, MF, 133K, 1/4 w, $\pm$ 1%	(01121) 19701 19701	(CS 1025) MF5C-1003-F MF5C-1333-F
A5C7 and A5C8 A5C9 A5C10 A5C11	11-28 (14-37) 13-68 12-2	Fixed, dipped mica, 82 pf, $\pm$ 2% Same as A5C1 Fixed, 3.3 μ f, 15V, $\pm$ 10% Fixed, 0.001 μ f, 100V	00853 (56289) 22229 72982	D153E820GO (192P1049R8) K3R3C15K 851-X5R-102K					
DIODES									
A5CR1 thru A5CR3	81-132	1N914	07263	1N914					
TRANSISTORS									
A5Q1 A5Q2 A5Q3 and A5Q4 A5Q5	81-194 81-115 81-140 (81-115)	Sprague TD100 2N3565 2N5087 Same as A5Q2	56289 07263 04713 (07263)	TD100 2N3565 2N5087 (2N3565)	A25 H.V. Feedback PC Board Assy. 950278)				
A5Q6 A5Q7 thru A5Q11 A5Q12 and A5Q13 A5Q14	(81-195) 81-189 81-169 81-72	Same as A11Q1 2N4917 2N3569 NPN, 2N699	(56289) 07263 07263 96214	(TD100) 2N4917 2N3569 2N699	CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
A5R1 A5R2 A5R3 and A5R4 A5R5	59-26.7K 59-26.1K 59-1K 71-136	Fixed, MF, 26.7K, 1/4 w, $\pm$ 1% Fixed, MF, 26.1K, 1/4 w, $\pm$ 1% Fixed, MF, 1K, 1/4 w, $\pm$ 1% Variable, comp., 250 Ω , 0.2 w, $\pm$ 30%	19701 19701 19701 71450	MF5C-2672-F MF5C-2612-F MF5C-1001-F U201R251B	A25C1	12-30	CAPACITORS Fixed, ceramic, 1.5 pf 6KV	56289	60-GA-V15
A5R6 and A5R7 A5R8 A5R9	34-10K 34-4.7K (34-10K)	Fixed, comp., 10K, 1/4 w, $\pm$ 5% Fixed, comp., 4.7K, 1/4 w, $\pm$ 5% Same as A5R6	01121 01121 (01121)	CS 1035 CS 4725 (CS 1035)	A25R1 thru A25R6	52-464K	RESISTORS Fixed, MF, 464K, 1 w, $\pm$ 1%	19701	MF8-4643-F
A5R10 and A5R11 A5R12 and A5R13 A5R14	34-560 Ω (34-10K) 34-5.6K	Fixed, comp, 650 Ω , 1/4 w, $\pm$ 5% Same as A11R6 Resistor fixed, comp., 5.6K, 1/4 w, $\pm$ 5%	01121 (01121) 01121	CS 5615 (CS 1035) CS 5625	SECTION 7				
A5R15 A5R16	34-4.3K 34-1.8K	Fixed, comp., 4.3K, 1/4 w, $\pm$ 5% Fixed, comp., 1.8K, 1/4 w, $\pm$ 5%	01121 01121	CS 4325 CS 1825	SCHEMATICS				
A5R17	71-135	Variable, comp., 1.5K, 0.2 w, $\pm$ 30%	71450	U201R152B	Schematics are included in the following order:				
A5R18 A5R19 and A5R20	(34-5.6K) 34-390 Ω	Same as A5R14 Fixed, comp., 390 Ω , 1/4 w, $\pm$ 5%	(01121) 01121	(CS 5625) CS 3915	PLUG-IN CHASSIS ASSEMBLY				
A5R21 A5R22 A5R23 A5R24 A5R25	(34-4.7K) 34-8.2K 34-1K (34-10K) 34-15K	Same as A5R8 Fixed, comp., 8.2K, 1/4 w, $\pm$ 5% Fixed, comp., 1K, 1/4 w, $\pm$ 5% Same as A5R6 Fixed, comp., 15K, 1/4 w, $\pm$ 5%	(01121) 01121 01121 (01121) 01121	(CS 4725) CS 8225 CS 1025 (CS 1035) CS 1535	A1 POWER SUPPLY PC BOARD ASSEMBLY 951907				
A5R26 A5R27 A5R28 and A5R29	34-330 Ω (34-330 Ω) 34-820 Ω	Fixed, comp., 330 Ω , 1/4 w, $\pm$ 5% Same as A5R26 Fixed, comp., 820 Ω , 1/4 w, $\pm$ 5%	01121 (01121) 01121	CS 3315 (CS 3315) CS 8215	A2 REGULATOR PC BOARD ASSEMBLY 951905				
A5R30	(34-4.7K)	Same as A5R8	(01121)	(CS 4725)	A3 FUNCTION GENERATOR PC BOARD ASSEMBLY 951888				
A5R31 A5R32 A5R33	(34-10K) 34-2.2K 34-220 Ω	Same as A5R6 Fixed, comp., 2.2K, 1/4 w, $\pm$ 5% Fixed, comp., 220 Ω , 1/4 w, $\pm$ 5%	(01121) 01121 01121	(CS 1035) CS 2225 CS 2215	A4 LINEAR POWER AMPLIFIER PC BOARD ASSEMBLY 951906				
A5R34 A5R35	(34-330 Ω) (34-1K)	Same as A5R26 Same as A5R23	(01121) (01121)	(CS 3315) (CS 1025)	A5 LEVELER AMPLIFIER PC BOARD ASSEMBLY 951088				
					D907376 B907397 D907373 C907368 C907371 D907033				







NOTES:

- UNLESS OTHERWISE SPECIFIED:
ALL RESISTOR VALUES IN OHMS, $\pm 5\%$, 1/4 W
ALL CAPACITOR VALUES IN MICROFARADS, $\pm 10\%$, 100V
- PREFIX REF DESIGNATOR WITH "ALL"
- FOR FIELDS SERVICE SUBSTITUTIONS USE (1D-100 SPRAGUE)
IN PLACE OF ALFRED NO. 81-194

*FACTORY-SELECTED

1/10/70

ITEM	REQD	PART NO	DESCRIPTION	DATE	BY
1		951088	SCHEMATIC DIAGRAM LEVELER AMPLIFIER (PIN MODULATOR) AS	25-68	951088
2		951088	SCHEMATIC DIAGRAM LEVELER AMPLIFIER (PIN MODULATOR) AS	25-68	951088
3		951088	SCHEMATIC DIAGRAM LEVELER AMPLIFIER (PIN MODULATOR) AS	25-68	951088
4		951088	SCHEMATIC DIAGRAM LEVELER AMPLIFIER (PIN MODULATOR) AS	25-68	951088
5		951088	SCHEMATIC DIAGRAM LEVELER AMPLIFIER (PIN MODULATOR) AS	25-68	951088
6		951088	SCHEMATIC DIAGRAM LEVELER AMPLIFIER (PIN MODULATOR) AS	25-68	951088
7		951088	SCHEMATIC DIAGRAM LEVELER AMPLIFIER (PIN MODULATOR) AS	25-68	951088
8		951088	SCHEMATIC DIAGRAM LEVELER AMPLIFIER (PIN MODULATOR) AS	25-68	951088
9		951088	SCHEMATIC DIAGRAM LEVELER AMPLIFIER (PIN MODULATOR) AS	25-68	951088
10		951088	SCHEMATIC DIAGRAM LEVELER AMPLIFIER (PIN MODULATOR) AS	25-68	951088
11		951088	SCHEMATIC DIAGRAM LEVELER AMPLIFIER (PIN MODULATOR) AS	25-68	951088
12		951088	SCHEMATIC DIAGRAM LEVELER AMPLIFIER (PIN MODULATOR) AS	25-68	951088
13		951088	SCHEMATIC DIAGRAM LEVELER AMPLIFIER (PIN MODULATOR) AS	25-68	951088
14		951088	SCHEMATIC DIAGRAM LEVELER AMPLIFIER (PIN MODULATOR) AS	25-68	951088
15		951088	SCHEMATIC DIAGRAM LEVELER AMPLIFIER (PIN MODULATOR) AS	25-68	951088
16		951088	SCHEMATIC DIAGRAM LEVELER AMPLIFIER (PIN MODULATOR) AS	25-68	951088
17		951088	SCHEMATIC DIAGRAM LEVELER AMPLIFIER (PIN MODULATOR) AS	25-68	951088
18		951088	SCHEMATIC DIAGRAM LEVELER AMPLIFIER (PIN MODULATOR) AS	25-68	951088
19		951088	SCHEMATIC DIAGRAM LEVELER AMPLIFIER (PIN MODULATOR) AS	25-68	951088
20		951088	SCHEMATIC DIAGRAM LEVELER AMPLIFIER (PIN MODULATOR) AS	25-68	951088
21		951088	SCHEMATIC DIAGRAM LEVELER AMPLIFIER (PIN MODULATOR) AS	25-68	951088
22		951088	SCHEMATIC DIAGRAM LEVELER AMPLIFIER (PIN MODULATOR) AS	25-68	951088

SHIPMENT DAMAGE CLAIM

The instrument should be tested as soon as it is received. If it fails to operate properly or is damaged in any way, a claim must be filed with the carrier. Have carrier agent inspect damage to instrument and packing crate and forward us a copy of his written report. You will then be advised of replacement or repair arrangements and disposition of the equipment. Please include model number, type number and serial number when referring to this instrument for any reason.

REPACKING FOR SHIPMENT

The instrument should be packed in the original carton. If unusable or not available, use a wooden box with approximately three inches of excelsior or other shock-absorbing material surrounding the instrument. If desired, packing services of a local transfer and storage company may be employed.

SINGER
INSTRUMENTATION



CHAMPION **N**^o. 55
CLASP 6 x 9

